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CONTENTS.

PAGE

Forty-eighth General Meeting :—

Coal as a Future Source of Oil Supply, by Sir ARTHUR DUCKHAM 3

Discussion : THE PRESIDENT, Sir JOHN CADMAN, Messrs. HACKFORD, CUNNINGHAM CRAIG, ANDERSON, LESSING, BRAITHWAITE, REILLY, STANDEN, PITT, HOWELL, and ORMANDY 13

Fiftieth General Meeting :—

The Lamp Method for Estimating Sulphur in Benzine, by J. S. JACKSON and A. W. RICHARDSON 26

Discussion : Messrs. THOLE, ORMANDY, ANFILOGOFF, HACKFORD, REILLY, EVANS, ORMANDY and SANDERS 27

The Laboratory Testing of Oil Shale for Oil and Ammonia Yield, by E. L. LOMAX and F. G. P. REMFRY 34

Discussion : Mr. W. H. MANFIELD 45

Crystal Palace Lectures 47

Current Bibliography, by ANDREW CAMPBELL 48

Fifty-first General Meeting :—

Boring in Palestine, by Captain PAUL H. MANGIN .. 57

Discussion : The CHAIRMAN, Mr. MAY, Col. PAUL, and Mr. DAVSON 74

Written communications by Dr. HUME and Captain MANGIN 78

Estimation of Sulphur by the Lamp Method, by F. ESLING 83

Discussion : The CHAIRMAN, Dr. THOLE, Messrs. MITCHELL, and LAWSON LOMAX.. 94

Fifty-second General Meeting :—

The Carbonisation of Lubricating Oils in Internal-Combustion Engines, by FREDERIC H. GARNER 98

Discussion : Messrs. ARCHBUTT, EVANS, GORDON PITT, Drs. LESSING, BLACKLER, and Mr. PARNACOTT .. 126

Dr. ORMANDY's Reply 133

Bibliography 139

Third Annual Dinner 149

Crystal Palace Lectures 161

Current Bibliography, by W. J. WILSON 162

Fifty-third General Meeting :—

Working of Petroleum by means of "Shafts" and "Galleries," by PAUL DE CHAMBRIER 177

PAGE

Discussion : The PRESIDENT, Mr. CUNNINGHAM CRAIG, Sir JOHN CADMAN, Dr. ORMANDY, and PAUL DE CHAMBRIER 190
Contributions from Messrs. C. N. BROMEHEAD, WILFRED E. GOODAY, ARTHUR W. EASTLAKE, I. A. STIGAND, and A. BEEBY THOMPSON 196
Reply by M. PAUL DE CHAMBRIER 200
Reply by Mr. GARNER 205
Further References 207
Erratum 207

Fifty-fourth General Meeting :—

The Crude Oils of Borneo, by J. KEWLEY, M.A., F.I.C. 208
Discussion : The PRESIDENT, Mr. KEWLEY, Dr. ORMANDY, Mr. ANFILOGOFF, Dr. DUNSTAN, Dr. LESSING, Mr. W. MACNAB, Mr. EVANS, and Prof. BRAME .. 221
Written communications by Mr. E. H. CUNNINGHAM CRAIG and Mr. I. A. STIGAND 230
Mr. JAMES KEWLEY'S Reply 232
Current Bibliography, by W. J. WILSON 234

Fifty-fifth General Meeting :—

The Education and Training of a Driller, by ALAN W. DAVSON, F.S.I., F.I.Ar. 253
Discussion : Prof. Sir JOHN CADMAN, Mr. GORDON PITT, Mr. CUNNINGHAM CRAIG, Mr. HUDSON HOBDEN, The PRESIDENT 265
Reply by Mr. A. W. DAVSON 272
Contribution from Mr. GEORGE HOWELL 274

Fifty-sixth General Meeting :—

The Mackenzie Oil-field of Northern Canada, by T. O. BOSWORTH, D.Sc., M.A., F.G.S., F.R.G.S. .. 276
Discussion : Mr. CUNNINGHAM CRAIG, Dr. H. M. AMI, Dr. J. A. L. HENDERSON, Dr. W. R. ORMANDY, Dr. T. O. BOSWORTH 291

Fifty-seventh General Meeting :—

Trinidad as a Field for the Study of the Origin of Petroleum, by P. CARMODY, F.I.C. 298
Discussion : The PRESIDENT, Gen. BRAKE, Mr. MACCARTHY, Sir JOHN CADMAN, Mr. CUNNINGHAM CRAIG, Mr. GORDON PITT, Mr. A. FRANK DABELL 313
Reply by Prof. CARMODY 320
Contributions from Messrs. S. BOWREY, W. J. REYNOLDS, T. MADGWICK 321

PAGE

The Relation between Alcohol-Water Solubility and Spontaneous Ignition Temperatures, by W. R. ORMANDY and E. C. CRAVEN 325

Some Notes on the Estimation of Sulphur and Chlorine by the Lamp Method, by S. BOWMAN, A.I.C. 334

Royal Aircraft Establishment Report, No. H.G. 410 .. 339

Royal Aircraft Establishment Report, No. H. 861 342

Current Bibliography, by W. J. WILSON 352

Fifty-eighth General Meeting :—

The Geology of the Egyptian Oil-field, by W. F. HUME, D.Sc., A.R.C.S., etc. 394

Discussion : Mr. CUNNINGHAM CRAIG, Prof. MADGWICK, Mr. BEEBY THOMPSON, Mr. GUTHRIE 412

Written communication by Mr. GUTHRIE 415

Reply by Dr. HUME 416

Notes on the Chemical Nature of Mineral Lubricating Oils, by A. E. DUNSTAN and F. B. THOLE 417

The System Ethyl Alcohol—Water—Aromatic Hydrocarbons from 30° C. to —30° C., by W. R. ORMANDY and E. C. CRAVEN 422

Current Bibliography, compiled by W. J. WILSON, A.G.G.I., A.I.C. 440

Abstracts, compiled by T. A. SMITH, B.Sc., F.I.C. 458

CONTENTS.

	PAGE
Council and Officers	i, ii
Committees	ii
General Notices :—	
Copyright	iv
Issue of Journal	iv
Changes of Address	iv
To Authors of Papers	iv
Special Meeting	v
Communications	vi
Appointments Register	vi
Library	vi
Advertisements in the Journal	x
List of Advertisers	x
Personal Notes of Members and Special Notices	x–xi
Reviews	xii–xvi
W. H. Dalton, Esq.	xvi
Forty-eighth General Meeting :—	
Coal as a Future Source of Oil Supply, by Sir ARTHUR DUCKHAM	3
Discussion: The PRESIDENT, Sir JOHN CADMAN, Messrs. HACKFORD, CUNNINGHAM CRAIG, ANDERSON, LESSING, BRAITHWAITE, REILLY, STANDEN, PITT, HOWELL, and ORMANDY	13
Fiftieth General Meeting :—	
The Lamp Method for Estimating Sulphur in Benzine, by J. S. JACKSON and A. W. RICHARDSON	26
Discussion: Messrs. THOLE, ORMANDY, ANFILOGOFF, HACKFORD, REILLY, EVANS, ORMANDY and SANDERS	27
The Laboratory Testing of Oil Shale for Oil and Ammonia Yield, by E. L. LOMAX and F. G. P. REMFRY	34
Discussion: Mr. W. H. MANFIELD	45
Crystal Palace Lectures	47
Current Bibliography, by ANDREW CAMPBELL	48

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Communications upon papers read at meetings, notices of personal movements, or other matter for which publication is desired in the next issue of the Journal, should be in the hands of the Editor on or before the last day of December, March, June or September as the case may be. Subsequent delivery may be too late for insertion.

The Council desire to draw the attention of authors to the serious increase in the cost of production. Papers, both for the Journal and for communication to the Institution, should be as concise and condensed as possible.

Special Meeting.

The President and Council, in view of the rapidly increasing membership and the urgent desirability of extending the usefulness of the Institution, consider that the time is now opportune for a discussion on the means to be adopted to increase the efficiency of the Institution. They understand that such an opportunity for free discussion would be welcomed by the members, and they propose therefore that the extra meeting which it is proposed to hold on the 22nd February next shall be devoted to this object. Under the circumstances it will be recognised that only members (including Associate members,

Students, and Associates) of the Institution will be eligible to attend at that meeting, and that on this occasion guests will not be invited.

Communications. The Council invite members to submit papers for the forthcoming session. Communications to the Institution will, subject to the approval of the Publication Committee, be published in the Journal.

Appointments Register. A Register will be kept at the Offices of the Institution for the convenience of firms requiring the services of members and for members requiring appointments, but on the distinct understanding that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library is in course of reorganisation in the new premises at No. 5 John Street, Adelphi, and may be consulted between 11 and 4 daily. Extensive additions are being made to the current and standard literature on Petroleum.

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Bulletin of Institution of Mining and Metallurgy.
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Shipbuilding and Shipping Record.
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Red Book (American).
Transactions of the Institution of Mining Engineers.
Publications from Department of Mines, Canada.
Quarterly Journal of School of Mines, Colorado.

And in future:

All United States' Bulletins relating to Petroleum Technology and Technical Papers.

The following Bulletins have been received from the U.S. Bureau of Mines and U.S. Geological Survey:—

Bulletin, 1919. Efficiency in the Use of Oil Fuel. By J. M. Wadsworth.

Bulletin 42, 1913. The Sampling and Examination of Mines' Gases and Natural Gas. By George A. Burrell and Frank M. Seibert.

Bulletin 114, 1916 (U.S. Bureau of Mines). Manufacture of Gasoline and Benzene-Toluene from Petroleum and other Hydrocarbons. By W. F. Rittman, C. B. Dutton, and E.W. Dean, with a bibliography compiled by M. S. Howard.

Bulletin 120, 1917 (U.S. Bureau of Mines). Extraction of Gasoline from Natural Gas by Absorption Methods. By George A. Burrell, P. M. Biddison and G. G. Oberfell.

Bulletin 134, 1916. The Use of Mud-Laden Fluid in Oil and Gas Wells. By James O. Lewis and William F. McMurray.

Bulletin 148, 1917. Methods for Increasing the Recovery from Oil Sands. By J. O. Lewis.

Bulletin 155, 1918. Oil-Storage Tanks and Reservoirs. By C. P. Bowie.

Bulletin 156, 1918. The Diesel Engine. Its Fuels and its Uses. By Herbert Haas.

Bulletin 162, 1919. Removal of the Lighter Hydrocarbons from Petroleum by Continuous Distillation. By J. M. Wadsworth.

Bulletin 394, 1909 (U.S. Geological Survey). Papers on the Conservation of Mineral Resources. Reprinted from Report of the National Conservation Commission, February, 1909.

Bulletin 541—A, 1913 (U.S. Geological Survey). Oil and Gas in the Northern Part of the Cadiz Quadrangle, Ohio. By D. Dale Condit. Gas from Mud Lumps at the Mouths of the Mississippi. By E. W. Shaw.

Bulletin 541—D, 1913 (U.S. Geological Survey). Oil and Gas near Green River, Grand County, Utah. By Charles T. Lupton. Petroleum near Dayton, New Mexico. By G. B. Richardson.

Bulletin 579, 1914 (U.S. Geological Survey). Reconnaissance of Oil and Gas Fields in Wayne and McCreary Counties, Kentucky. By M. J. Munn.

Bulletin 581—A, 1914 (U.S. Geological Survey). Oil Shale of North-Western Colorado and North-Eastern Utah. By E. G. Woodruff and David T. Day.

Bulletin 641—A, 1916 (U.S. Geological Survey). Ozokerite in Central Utah. By Heath M. Robinson.

Technical Papers received from the U.S. Bureau of Mines:—

Technical Paper 25, 1912. Methods for the Determination of Water in Petroleum and its Products. By Irving C. Allen and Walter A. Jacobs.

Technical Paper 32, 1913. The Cementing Process of Excluding Water from Oil Wells as practised in California. By Ralph Arnold and V. R. Garfias.

Technical Paper 37, 1913. Heavy Oil as Fuel for Internal-Combustion Engines. By Irving C. Allen.

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Technical Paper 49, 1914. The Flash Point of Oils. By Irving C. Allen and A. S. Crossfield.

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Technical Paper 70, 1914. Methods of Oil Recovery in California. By Ralph Arnold and V. R. Garfias.

Technical Paper 72, 1914. Problems of the Petroleum Industry. Results of Conferences at Pittsburg, Pa., August 1 and September 10, 1913. By Irving C. Allen.

Technical Paper 79, 1914. Electric Lights for Use about Oil and Gas Wells. By H. H. Clark.

Technical Paper 87, 1916. Methods of Testing Natural Gas for Gasoline Content. By G. A. Burrell and G. W. Jones.

Technical Paper 104, 1915. Analysis of Natural Gas and Illuminating Gas by Fractional Distillation at Low Temperatures and Pressures. By G. A. Burrell, F. M. Seibert and I. W. Robertson.

Technical Paper 117, 1916. Quantity of Gasoline Necessary to Produce Explosive Conditions in Sewers. By G. A. Burrell and H. T. Boyd.

Technical Paper 120, 1915. A Bibliography of the Chemistry of Gas Manufacture. By W. F. Rittman and M. C. Whitaker.

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Technical Paper 130, 1916. Underground Wastes in Oil and Gas Fields and Methods of Prevention. By William F. McMurray and James O. Lewis.

Technical Paper 131, 1916. The Compressibility of Natural Gas at High Pressures. By G. A. Burrell and I. W. Robertson.

Technical Paper 134, 1916. The Use of Mud-Laden Fluid in Oil and Gas Wells. By James O. Lewis and William F. McMurray.

Technical Paper 142, 1916. Vapor Pressures at Various Compounds at Low Temperatures. By J. A. Burrell and I. W. Robertson.

Technical Paper 158, 1917. Compressibility of Natural Gas and its Constituents with Analysis of Natural Gas from 31 cities in the United States. By G. A. Burrell and I. W. Robertson.

Technical Paper 161, 1917. Construction and Operation of a Single Tube Cracking Furnace for Making Gasoline. By C. P. Bowie.

Technical Paper 163, 1916. Physical and Chemical Properties of Gasoline sold throughout the United States during the Calendar Year 1915. By W. F. Rittman, W. A. Jacobs and E. W. Dean.

Technical Paper 181, 1917. Determination of Unsaturated Hydrocarbons in Gasoline. By E. W. Dean and H. H. Hill.

Technical Paper 185, 1918. Use of the Interferometer in Gas Analysis. By Frank M. Seibert and Walter C. Harpster.

Technical Paper 209, 1919. Traps for Saving Gas at Oil Wells. By W. R. Hamilton.

Technical Paper 214, 1919. Motor Gasoline Properties, Laboratory Methods of Testing and Practical Specifications. By E. W. Dean.

Technical Paper 216, 1919. Vitiation of Garage Air by Automobile Exhaust Gases. By G. A. Burrell and A. W. Gauger.

Technical Paper 232, 1920. Absorption as Applied to Recovery of Gasoline Left in Residual Gas from Compression Plants. By W. P. Dykema and Roy O. Neal.

Technical Paper 257, 1920. Waste and Correct Use of Natural Gas in the Home. By Samuel S. Wyer.

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Peat : Its Use and Manufacture. By Bjorling and Gissing.

Commercial Peat : Its Uses and its Possibilities. By F. T. Gissing.

Calorific Power of Coal Gas. By J. H. Coste, F.I.C.

Fuel : Gaseous, Liquid, and Solid. By J. H. Coste and E. R. Andrews.

The Chemistry of the Colloids. By Dr. V. Poschl. Translated by Dr. H. Hodgson.

Land and Marine Diesel Engines. By Supino and others.

Diesel Engine Design. By E. Mortimer Rose.

Carburettors, Vaporisers and Distributing Valves. By Edward Butler.

Coal and its Economic Utilisation. By Prof. W. A. Bone, F.R.S.

Corrosion and Preservation of Iron and Steel. By Cushman and Gardner.

Lubricating Oils, Fats and Greases. By George H. Hurst. 3rd edition.

Mineral Waxes. By Rudolph Gregorius. Translated from the German by Chas. Salter.

Shale Oils and Tars and their Products. By Dr. W. Scheithaner. Translated from the German by Chas. Salter.

By-Products of Coal Gas Manufacture. By K. R. Lange, Ph.D. Translated from the German by Chas. Salter.

American Petroleum Industry. By Raymond Foss Bacon, Ph.D., and William Allen Hamor, M.A. 2 volumes.

Second and Third Report on Colloid Chemistry and its General and Industrial Applications. British Association.

Engineering and Mining Journal of New York, August 14th, 1920, containing article on Petroleum in Persia and the Near East. By Edmund M. Spicker, U.S. Geo. Survey.

The following Books have been presented by the Director of the Geological Survey, Great Britain :—

Summary of Progress of the Geological Survey of Great Britain for 1918 and 1919.

Special Reports on the Mineral Resources of Great Britain, Vol. VII, Part 1 and Part 2.

And from the Scottish Office of the Geological Survey :—

Central Coalfields of Scotland. Areas :—II, IV, V, VII and VIII.

Presented by Mr. E. B. Forbes :—

Minutes of Proceedings of the Institution of Civil Engineers. Vol. CCV. Part I, 1917–18 ; Part II, 1917–18.

The following have been presented by the Authors :—

Popular Oil Geology. By Victor Ziegler. 2nd edition. 1920.
Prospecting for Oil and Gas. By L. S. Panyity. 1920.
Mid-Continent Oilfields of America. By Dr. T. O. Bosworth.
Oil Finding. By E. H. Cunningham Craig. 1920. 2nd edition.
Colloidal Fuel : Composites of Oil and Carbon. By Lindon W. Bates.
The Oil Shale Industry. By Dr. Victor Clifton Alderson.
Historique de Pechelbronn. 1498–1918.

The attention of members is drawn to the new supplement of the Journal which deals with current Petroleum literature. To make this section of the maximum usefulness it is necessary that there should be full co-operation between chemists, engineers and geologists, and that matter which has inadvertently escaped notice shall be immediately sent in to the Editor. The Institution is indebted to Mr. Andrew Campbell for the compilation of the bibliography.

Advertisements in the Journal. A limited number of Advertisements of firms interested in the Petroleum Industry may be inserted in the Journal. Application for terms, etc., should be made to the Secretary.

LIST OF ADVERTISERS.

(Members are desired, when making enquiries or placing orders with advertisers, to mention that they have seen their announcement in the Journal.)

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PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

The SECRETARY represented the Institution at a Conference called by the Air Ministry to consider the production of lubricating oil from Imperial sources.

Mr. F. PARISH, at the Independent Oil Men's Association meeting in Denver, U.S.A., is presenting a paper on "The Specifications and Nomenclature of Lubricating Oil." The need for this is apparent when

it is remembered that no less than one thousand different named varieties of lubricating oil are on the market.

The LIBRARIAN, who is at the moment in the throes of card indexing, not only the Library but also all the references therein contained, wishes to draw the attention of members of the Institution to the list of additions to the Library. It is hoped that in the near future a complete Catalogue may be issued, but in the meantime those members who may need assistance in tracing a reference or who wish to consult the already voluminous Petroleum literature will do well to call on the Librarian at 5 John Street.

Papers on Colloidal Fuel by Messrs. LINDON BATES and O'NEILL are unavoidably omitted from the present issue of the Journal. It is hoped that they will appear in the April number.

Mr. EDWARD DIXON has left for Burma.

Mr. ALEXANDER DUCKHAM has returned from Trinidad.

Mr. J. E. MARSHALL HALL has returned from Africa.

The SECRETARY has received enquiries for (1) a first-class Field Manager, fully experienced in the Rotary Drill; and (2) an experienced Stores Manager, thoroughly acquainted with Oilfield management. The SECRETARY will be pleased to hear from anyone interested.

Mr. JAMES W. BURFORD is returning to Lobitos, Peru, on the 5th ult.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

MINERAL OIL, KIMMERIDGE OIL-SHALE, LIGNITES, JETS, CANNEL COALS, NATURAL GAS.

ENGLAND AND WALES.

THE Ministry of Agriculture and Fisheries desire to give notice of the publication of a second edition of the Seventh Volume of the Special Reports on the Mineral Resources of Great Britain, which has been prepared by the Director of the Geological Survey in response to numerous enquiries that arose through conditions brought about by the late War.

In the second edition of this Memoir the account of mineral oil, and of the explorations now being made for it in Great Britain, is brought up to date of going to press (June, 1919). In the chapter on Kimmeridge oil the results of analyses made by the Mineral Resources Development Bureau, and further notes on the works in progress in Norfolk have been added. The records of occurrences of cannel coals have been greatly expanded, as a result of recent investigations in all the coalfields of England and Wales.

Copies may be obtained through any bookseller, from the Director-General, Ordnance Survey Office, Southampton. Price 5s. net.

REVIEWS.

"Prospecting for Oil and Gas." By L. S. Panyity. Pp. xvii, 249, 8vo, New York (*John Wiley & Sons*), and London (*Chapman & Hall, Ltd.*). 1920. 18s. net.

The aim of this useful little handbook is primarily to disabuse the public mind of the too-common idea that the discovery of oil and gas is a mere matter of chance, by explaining the methods of geological research and deduction with as little use as possible of the technicalities which to those unacquainted with that science, or without the leisure for its detailed study, make sealed books of the many treatises written for proficients therein. A secondary purpose of the work is to serve as a preliminary textbook for students who contemplate a career in direct connection with petroleum or natural gas.

A much-condensed rehearsal of the leading characteristics of natural hydrocarbons and of the general principles of geology is followed by a fairly full exposé of the conditions affecting accumulation of oil and gas, and of the methods of determining and recording the geological structure, as the most important factor in the concentration of the desired mineral fluids, where such are present.

Then comes the methods of locating sites, drilling and gauging wells and promoting their yield. There are appended generalised sections in several American States, mathematical and gravity tables.

In a work of this general character, there is necessarily a mixture of the personal observations of the author with those of others,

Acknowledgment is made of all the more extensive of direct excerpts, besides the prefatory mention of official and independent publications consulted, and of personal communication of practically-tested "wrinkles."

This feature of combination of sound theory with actual experience renders the work of much value to those who, without previous acquaintance with geology, are yet called upon to select locations, or to combat difficulties encountered in subsequent operations, success in which involves a grasp of the geological conditions there obtaining. Where a little knowledge (of a different region) may well prove to be a dangerous thing, recognised ignorance may enforce such study, under the tuition of a work like this, as to effect an adequate conception of the problems presented, and their satisfactory solution.

W. H. D.

"The Oil Shale Industry." By Dr. V. C. Alderson, President of the Colorado School of Mines. Pp. xiv, 175, 15 plates, 8vo, New York (*F. A. Stokes Co.*). 1920.

Dr. Alderson here presents us with a compact and useful summary of the leading facts connected with oil shale and the practically new industry which has arisen therein, in consequence of the realisation by many perspicacious minds of the approaching, if not imminent necessity of a succedaneum to the stores of mineral fuels at present in utilisation, coupled with the development in methods of use that calls more and more insistently for fluidity as an essential character.

With this indispensable factor must be associated high calorific value, amplitude of supply, and economy in production. Defect in one or more of these respects detracts from the utilisation of coal and peat, whilst against the proposed substitution of alcohol these and other considerations militate yet more strongly. Of liquid fuels, petroleum is assuredly the best in regions not favoured with natural gas, and the early future will assuredly find the main supply of it in the enormous bulks of shale that need only skilled treatment to produce in ample quantity any desired oils that can be separated from crude native petroleum—benzine, kerosene, lubricant, or other hydrocarbons of commercial value.

Whether the chief oil-shale field of the United States, that of Colorado, Utah, Nevada and Wyoming, will eventually prove to be the largest

in the world, in respect either of area or output of oil, or will be surpassed by other regions yet to be explored, is "on the knees of the gods."

We are glad to see Dr. Alderson's name on our list of members, and his work in our library.

"Coal in Great Britain: the Composition, Structure and Resources of the Coalfields, Visible and Concealed, of Great Britain." By WALCOT GIBSON, D.Sc., F.G.S. Pp. viii, 311, 8 plates, 8vo, London (*Edward Arnold*). 1920. Price 21s. net.

This is a most useful and comprehensive summary of the more important data concerning the structure, etc., of our coalfields, presented in his usual lucid style by one of our leading authorities on Carboniferous correlation, whose work on the staff of the Geological Survey covers some thirty years.

Although petroleum is mentioned only in respect of its occurrence, in unascertained quantity, in the Lower Carboniferous rocks of Derbyshire and Nottinghamshire, the work may be consulted with advantage in respect of cannel, blackband, ironstone and oil-yielding coals, likely in future to be utilised for distilling purposes.

It is needless to expatiate on its value to the wider circle interested generally in our national coal-production.

"Lubricating and Allied Oils." By ELLIOTT A. EVANS. (*Chapman & Hall, Ltd.*) 9s. 6d. net.

The author is well known to petroleum technologists as the chief chemist to one of the principal lubricating oil firms, and has written this volume primarily "to assist chemists in compiling specifications, and examining lubricating oils, also to give engineers an insight into the application and properties of such oils, and the interpretation of their specifications."

The ten chapters of the book may be considered under three headings, the first three (comprising ten pages) being devoted to The History of Petroleum, Oil Refining, and Occurrence of Fatty Oils. Oil Refining deals solely with mineral oils, and is but a short chapter of some ninety lines. One must question the author's statement that "broadly the oil is divided into three main groups, namely, inflammable, illuminating, and lubricating." It is a very loose use of terms and may be

misleading. Is one to draw the conclusion that illuminating and lubricating oils are not inflammable? No mention is made of other products obtained from crude oils. Sulphur compounds are dismissed in five lines. This chapter is decidedly "thin" and the succeeding chapter on Fatty Oils is also scanty. Dealing with oil extraction from seeds, etc., we are told that "sometimes the oil is extracted with solvents, and subsequently the petroleum spirit, or whatever solvent is used, is distilled off." The present practice is to avoid the use of such highly inflammable solvents as petroleum spirit, but no mention is made of the widely used non-inflammable solvents, chiefly chlorine derivatives of the hydrocarbons, like tetrachloroethane.

The following three chapters deal with physical and chemical tests, and the author's practical experience enables him to deal adequately with these. One point of merit is his treatment of the flash-point determination. He gives a concise summary of sources of error, and amongst these attention may be specifically drawn to errors due to variation in the time of opening and closing the slide. Although with the testers for low-flashing oils (illuminating oils) the variation in the time of opening was not found by Harker and Higgins to materially affect the results, this factor, in conjunction with the time intervals between applying the test flame (dependent with testers for high-flashing oils on the rate of heating) is a matter for investigation, for the two factors probably account for the considerable discrepancies between tests by different observers. Attention is directed to the rate of stirring, which when too rapid alters the ratio of exposed surface of oil to air space, and gives a low test. In one well-known form of tester the tendency to rapid stirring is very great because of the hand-wheel drive and the unnecessarily high gearing.

The section dealing with viscosity is very good, and the author has reproduced the valuable conversion tables for Engler, Saybolt and Redwood instruments published by The American Society for Testing Materials (1915). Dealing with the important matter of demulsification the author refers to Mr. Arnold Phillip's apparatus and method, but considers "the apparatus is perhaps too elaborate for laboratories where oils are not frequently examined," and considers the simple shaking test of 100 c.c. of oil with 100 c.c. of water for one minute "sufficiently accurate for general purposes." It is doubtful whether satisfactory tests can be obtained without mechanical agitation, and

this section would have been improved by reference to the Herschel apparatus adopted by the United States Bureau of Standards.

A useful chapter on the Oxidation of Petroleum is followed by a chapter on "Oleography," in which reference is made to the important work of Langmuir, Hardy, and others. The final two chapters on the Selection of Lubricants and Oils Employed deal with the subjects in a very practical manner. One could, however, wish for the omission of three pages giving the names of one make of proprietary oils suitable for motor cars of different makes. The trade element should be kept out of technical literature.

The book is well produced, with clear illustrations and a good index; so complete, indeed, that we find Noah's Ark, and, amongst other notabilities figuring in it, Lot's Wife, Psalmist, Old Billy Smith, Peter the Great, and Jupiter! Their connection with lubricants was, however, probably remote.

J. S. S. B.

W. H. DALTON, ESQ.

Members of the Institution will learn with regret that Mr. W. H. Dalton will no longer edit their Proceedings and Publications. During the past six years he has acted as Honorary Editor and Librarian for the Institution, and all those who have come in contact with him during his term of office will realise how wholeheartedly and enthusiastically he has put his energies and talents, in the completest way, at the disposal of his fellow members. As a master of the art of writing English he has few equals, and his Editorials were always a special joy for those readers who appreciated the apt expression of a well-conceived idea. The best wishes and thanks of the Institution are his well-deserved portion.

A. E. D.

The Forty-eighth General Meeting of the Institution was held in the rooms of the Royal Society of Arts on Tuesday, October 19th, 1920, Sir Frederick Black, K.C.B., President, occupying the Chair.

At the opening of the meeting, the Secretary read the names of 52 new members who had joined the Institution.

The President said at the opening of the session there were two or three announcements he desired to make. First of all, the members had to express their sense of the losses that had occurred to the Institution through the hand of death, since last session. During the past year the Institution had to mourn the loss of Admiral Lord Fisher, who was one of the Institution's Honorary Vice-Presidents. Lord Fisher's reputation was national, and his fame was world-wide. Nevertheless he thought the Institution should put its little laurel in his wreath of fame, because of the very great interest he took in all petroleum matters and the great and timely stimulus he gave to the use of heavy oil fuel in the Navy. The members would recollect Lord Fisher's advocacy in the last few months of his life of the use of Diesel engines for marine purposes. The Institution also had to mourn the loss of Professor Blundstone, a Member of the Council and one of the Vice-Presidents. Ill-health had prevented him taking any active part in the proceedings during the last few years, but many would remember his earlier career as an oil geologist. The last he (the President) remembered of his principal pieces of work was his membership of the Government Commission which about seven years ago examined the Persian oilfields. Last, but not least, the Institution had had the misfortune to lose its Secretary, Mr. Rogers, a man who by his courtesy and kindness of heart and by his work for the Institution had endeared himself to everyone who came into contact with him. The Council had elected Mr. George Howell in Mr. Rogers' place. Mr. Howell was known to all the members. He had read a paper before the Institution on behalf of another member; he was a man who knew oilfields; he was a geologist and he was already making his mark as a very active worker in the post of Secretary, in which he was sure he would have the general support of the members.

He also desired to mention the highly satisfactory progress which the Institution had been making, particularly in its membership during the past year. Something like 100 new members had been enrolled. He particularly desired to draw attention to the work that had been done already, and was still being done, in the improvement of the Library. Those who had time to call at 5 John Street would see that the books there were well arranged, and the Council was voting a

certain amount of money from year to year in the hope that, with the best advice that could be obtained as to the books that ought to be purchased and the books that ought to be weeded out, the Institution's Library would be the best dealing with the subject in the United Kingdom. Perhaps in the course of time the Institution would have greater ambitions even than that.

Then he thought he ought to say a few words about the series of popular lectures which were delivered during the summer holidays at the Crystal Palace. He would not mention the names of the heroes who sacrificed their well-earned holidays to give those lectures, but the Council was very pleased indeed with the attendance at them except on one very wet night. It was hoped to publish the lectures in book form, and if that was well taken up, as the Council trusted it would be, it was expected that a certain amount of money would be made, which would be devoted to the further improvement of the Library.

It was now his pleasure to introduce Sir Arthur Duckham, with whom he served at the Ministry of Munitions. It was impossible for him to give a list of the various offices that Sir Arthur filled at the Ministry. He began on the Inventions Board, and when last he heard of him Sir Arthur was a member of the Council of the Ministry and head of the department responsible for aviation supplies. He recalled particularly the fact that when he used to go about the country sometimes with Sir Arthur he used to tell him of his great interest in the subject of economy in fuel. On one occasion he pointed to some big gas holders in the south of London and said that that was where quite early in his life he began to learn something about what could be obtained out of a piece of coal. Beginning early, Sir Arthur had continued that study all his life. Sir Arthur once told him that he was going to make his son a perfect phenomenon in the way of a fuel engineer; he would know everything that was to be known about the best use that could be made of all the products that could be extracted from coal. There was one thing that Sir Arthur was very modest about and that was his (Sir Arthur's) connection with the Coal Commission, but the knowledge that he obtained of the coal industry at that time was no small part of his qualifications. The members might think it was a rather curious thing that a paper should be read on the obtaining of oil from coal at a time when there might not be any coal from which to get the oil, in view of the coal strike which was now taking place. It reminded him rather of that historic lady, Mrs. Glass, who wrote a cookery book and when dealing with jugged hare said: "First catch your hare and then jug it." He thought, however, the members all realised that, if there was to be a temporary scarcity

of coal, there could be no more appropriate time to take stock of the situation and make use of the driving force of scarcity than by considering all the ideas that could be developed with the object of making greater use of the fuel which had been supplied by nature.

The following paper was then read:

Coal as a Future Source of Oil Fuel Supply.

By Sir Arthur Duckham, K.C.B., M.I.C.E.

Gentlemen,

During the War I served under your President, Sir Frederick Black, and I often discussed with him the industrial future of this country. He, therefore, knew that my interests lay very largely in fuel conservation and the heat treatment of coal, and in consequence he asked me to read a paper on this subject to your Institution.

Although getting on in years, I am afraid I am of a sanguine temperament and chose a special phase of this subject, i.e., the obtaining of fuel oil from coal, thinking that I could give a close approximation of the industrial value of the different processes.

With this end in view, I have been making close enquiries of my technical friends, and have been diligently delving into books and pamphlets written by experts.

The conclusion at which I have arrived is, that it is almost impossible to make any definite statement to-day as to the best method of treating coal to obtain the best value in oils and tars. In these circumstances, therefore, I propose to give you a general outline of the situation as I see it, and to make some suggestions as to the most probable line of development.

When we look back to 1914 and compare the industrial conditions then existing with those of to-day, we are amazed. Only six years of time have elapsed since 1914, but to-day we live in a world so changed that more than a generation might have passed.

In view of the great changes caused by the War, it is necessary to free one's mind from old opinions, and to formulate lines of progress in accordance with the changed circumstances and altered tendencies.

Preliminary Considerations.—With the growth of civilisation, the needs of the community have become more and more complex. To meet these needs an improved supply of heat, light and power has been essential.

In past times, wood supplied heat, simple vegetable or animal products provided light, and power was obtained from natural forces, such as wind and water, or by human and animal effort.

As the needs of the community increase in geometrical and not in arithmetical progression, it was soon found that these primitive sources and forms of energy were inadequate. Coal took the place of wood as the source of heat, gas distilled from coal became the source of light, and mechanical power was obtained by harnessing steam generated in coal-fired boilers.

Before the attainment of a supply of mechanical power, practically unlimited in quantity and application, power had been the least considered of that great industrial and domestic triumvirate—heat, light and power—but rapidly power assumed supremacy.

The discovery and exploitation of the coal measures in Great Britain and the rapid application to industry of the energy so provided gave this country a tremendous start in industrial development. Other countries did not enjoy at that time so favourable a position, constitutionally, geographically or geologically. North America was naturally the country next best situated for industrial development, being lavishly favoured by Nature and freed from the continual unrest which prevented industrial development on the continent of Europe.

The discovery of mineral oil in the United States gave a fresh impetus to the production of energy. Used first as a source of heat, and so of power, through the medium of steam boilers, rapidly recognised as a lighting medium, it was only tardily realised that the products of the crude oil, used as a direct power producer in internal combustion engines, provided means of transport which have absolutely revolutionised the domestic and industrial life of the community.

The possibilities of the internal combustion engine working on oil fuel have been demonstrated in the recent War. For the first time, mechanical devices have taken part in land fighting. Man is no longer the unit, but machines, approaching in potentiality the great engines of destruction used in naval warfare, have been utilised and have broken through all human resistance.

Mineral oil, first developed as a ready form of heat and light in the countries where it abounded, was soon found to be so convenient to transport, supply and apply, that its use became universal. The internal combustion engine has now made oil supplies not only desirable, but indispensable. It has always struck me that it is an extraordinary coincidence that the source of power should also provide the source of lubrication.

To-day there is a world shortage of fuel. The War has closed down many sources of supply. There has been an abnormal upheaval in the position of the workers; the hours of work are shorter and the output per man hour has dropped.

With the growth of the population and the many needs of the community, the railways, especially about towns, have become congested, and the traffic in our streets has become a problem of great difficulty. To-day the community is not obtaining the same quantity of fuel as in pre-War days. On the other hand, the community requires a greater expenditure of energy derived from fuel per head of the population than ever before.

In the past, solid fuel has been transported by rail from the pits through to works and depots, man-handled to the stores or cellars, again man-handled to the boiler, furnace or grate, burnt wastefully, and then the ashes have had to go through the reverse process. I do not believe in future that we shall be able to afford the transport facilities for moving the coal on the congested railway lines leading to large towns. We shall have to restrict the transport of solid fuel and ashes through the congested streets. We shall not be able to afford the labour required for all this work, neither shall we in future be able to obtain labour to perform the arduous work of handling solid fuel, and clearing and removing ashes from boilers, furnaces or grates. Further, modern practice has already shown the very great advantages of oil fuel for bunkering and for stoking on board ship. Solid fuel must gradually die out for marine work. Oil fuel will take its place. Solid fuel will be displaced for locomotives and our trains will be fired with liquid fuel (and here I may say that, in liquid fuel I include a mixture of solid and liquid fuels in the state commonly known as "colloidal") so that we get a colossal and ever-increasing demand for oil fuel.

Lines of Development.—How is this demand to be met? At the present time there is a shortage of liquid fuel; the demand exceeds supply and is only restricted by high costs. Given a cheap supply of liquid fuel, the demand would increase many times.

It is, however, not possible to think of liquid fuel as the general means of supplying heat and power. On the other hand, I think it clear that the use of solid fuel will die out under the stress of modern conditions, which demand efficiency in the use of labour and the conservation of our national asset—coal.

What other sources of energy are available?

Electricity has proved itself a convenient and economical method of transmitting energy for the purposes of providing light and power, and undoubtedly a cheap supply of electricity generated under economical conditions is a necessity for this country, but no one would to-day consider the generation and transmission of electrical energy for the purpose of providing heat units for general industrial and domestic needs as meeting the case. The average heat economy of electrical generation and transmission to-day does not equal 10 per cent. It is

fully realised that this uneconomical figure can be greatly improved on, but it will be many years under ordinary conditions before the efficiency reaches 20 per cent. It is unthinkable to transmit heat units by a method which loses at least 80 per cent of the original heat in generation and transmission.

There remains one other method of transmission of heat units from the coal pit, the source of the fuel supply, to the industrial or domestic user, and that is gas, and it is my belief that the industrial future of this country lies in the conversion of the coal at the pit's mouth into liquid and gaseous fuels. Liquid fuel will be recognised as the medium for providing energy for all transport on land, sea or air, with the exception of electrical transport for congested areas, while gaseous fuel will be used direct for the great majority of heating purposes and for the generation of electricity, either by means of steam plants or engines.

Full experience has been gained in America of the transmission of gas over long distances, and there is no question that, starting in the big industrial districts which lie near the coalfields, gas can be supplied in sufficient quantities and can economically replace solid fuel.

The supply of oil for fuel is a necessity. Our only direct source of supply, which would in any way meet requirements, is our coalfields. The late War has proved that oil is indeed the backbone of all military effort. Without oil for lubrication, for transport, for explosives, no nation could possibly continue fighting.

What was once Great Britain's strength has become to a great degree Great Britain's weakness. The submarine has become so great a danger that should another war come, it is possible this island might indeed be isolated and cut off from all outside sources of oil supply. It is therefore essential for national as well as economic necessity to develop supplies of oil fuel at home.

The above brief résumé gives my opinion of the proper line of development. There is in our country at the present time a colossal waste of fuel. By proper conservation we should be able to get the same results with an expenditure of less than half the fuel that is consumed to-day.

It has always seemed a great pity to me that the Government should have been mesmerised by the word " electricity " and the day dreams of the electrical fanatic. They have appointed Electrical Commissioners. They should have appointed Heat, Power and Light Commissioners, whose duties should be to foster fuel conservation on general lines, and not think only in terms of electricity. I trust that the duties of the Electrical Commissioners will be extended by the Govern-

ment to embrace these other duties, and that gentlemen here present will use their influence to that end.

For the purpose of this paper I have endeavoured to obtain definite comparisons and figures showing the efficiency of the gasification of coal at the pit's mouth, and the distribution of the gas and liquid fuel to the user in the place of coal, but it is almost impossible to give either financial or thermal balance sheets for which I could vouch and which would be comparable.

There are even difficulties in giving the balance sheets of old and well-tried processes—so many factors are variable. Many balance sheets of new processes have been given from time to time; these have had for their principal object the raising of money from the general public for the flotation of companies, and are therefore not of the character to satisfy a meeting such as this.

In placing before you the different processes for the heat treatment of coal for the purpose of transforming heat units from solid to gaseous and liquid forms, I would remind you that I have been closely connected with one special form of plant for such purpose for many years, that is the continuous carbonisation of coal in vertical retorts. I have endeavoured, however, to free my mind of all prejudice and I would ask you to take any criticism of existing systems as being made with the sole purpose of elucidating the problem and endeavouring to obtain the best result for the nation.

Gasworks.—The best known method of heat treatment of solid fuel is the carbonisation of coal at the gasworks. The prime object of such carbonisation was the manufacture of coal gas for the purpose of lighting, the light being obtained from the luminous flame of the coal gas consumed in a specially constructed burner. Starting as a low temperature process, it gradually became, with the improvement of materials and of construction and advanced knowledge, a high temperature process. The quality of the tar oils obtained changed during this evolution. High temperature meant higher through-puts for the plant, less capital cost, higher yield of gas, less labour and a better financial result, the solid residue gradually finding a ready though somewhat fluctuating market. The discovery of the Welsbach gas mantle and the lowering of the price of the gas, due to improved methods, considerably increased the public demand for gas, while the possibility of using the gas for heating, cooking and power purposes further increased the importance of the gas supply to the community.

Gas undertakings were, however, greatly hampered by antiquated and restrictive legislation and were not able to take advantage of the possibilities presented by the new developments in heating, lighting

and power. Further, during the War, the existing restrictive legislation as to raising capital, coupled with high costs, definitely prevented the same advance being made as in other industries. Now that many of these restrictions have been removed or relaxed, it is possible to forecast the immediate lines of gasworks development.

There are, roughly speaking, two forms of carbonising plant in use in gasworks—horizontal fireclay retorts, charged and discharged by means of machinery, and vertical retorts constructed so that the coal travels continuously through by gravity.

The advantage of the horizontal retorts is that they already exist in most works, have a low capital cost, and can more readily be adapted to treat varying forms of coal. The disadvantages of horizontal retorts are obvious:—The large ground space they take up, the arduous conditions which they impose on the workmen, the amount of labour needed, the waste of heat in the discharge of hot coke, and the unavoidable nuisance caused by smoke, dust and steam in the working operations.

Among the advantages of the continuous working vertical retorts are the small ground space required, the absence of all nuisance, the good working conditions, and the increased make of gas and residuals. The disadvantages are the high capital cost and the fact that the retorts are more sensitive than horizontal retorts to changes of quality in the coal. Vertical retorts can and do carbonise any quality of coal very successfully so long as the quality remains substantially constant, but quick changes from, say, Derbyshire to Durham coal, from a light to a heavy caking coal, must of necessity upset the efficiency of the plant and give extra trouble in working.

During the War, the restrictions as to the candle power of the gas allowed to be supplied were relaxed, coal was also scarce and everyone endeavoured to obtain as much gas from the coal as possible. It had occurred to several people before the War that the heat in the coke should be utilised for the formation of water gas by passing steam through the hot coke. During the War it was possible to put these ideas into practice, and remarkable results in continuous-working vertical retorts were obtained. It became possible with steaming to obtain over 20,000 cubic feet of very serviceable gas per ton of coal instead of 12,000. It was further found that the water gas ascending the retort protected the hydrocarbons generated from the coal, and so gave a further increased make of gas and lighter tar oils.

The development of this process is to increase the temperatures about the bottom of the retorts and to highly superheat the steam before it enters the retorts. Further, the hot waste gases from the plant are being passed through waste heat boilers and more than the quantity of steam required for steaming the retorts is obtained in

return for a small extra capital expenditure and the cost of the power required to drive the fan on the outlet of the boilers.

There is a distinct limit to the use of steam in vertical retorts. It is not economical beyond a certain point to force heat through a fireclay wall to a charge in the retort for the purpose of making water gas, and although by this means the total gasification of the carbon in the charge has been achieved, the heat and financial balance sheets show this to be uneconomical.

This is undoubtedly the line of advance in gasworks practice, but from a National viewpoint I object to the conveyance of the coal to the gasworks, and the removal of the coke. The coal pit is the proper place to make gas, and pipe lines are the proper means of conveying heat units from the coalfields to the centres of distribution.

As far as oil is concerned, the vertical retort gives better tar oil results than the horizontal retort. Carbonisation of coal in vertical retorts is really fractional destructive distillation. The products of distillation are drawn away as made and have to pass through no higher temperature than that at which they are evolved, whilst if water gas is made at the same time in the retort this process protects the hydrocarbons and gives a greater quantity of a lighter quality tar.

Coke Ovens.—The next most general form of heat treatment of coal is in coke ovens. In early days the coal was treated in bulk in what is termed beehive ovens. The only product of these ovens was coke, the gaseous and liquid products of distillation being destroyed in the process. As there is no true recovery of tar oils from this process, we can pass on to the by-product recovery oven.

The form of these ovens and the method of working will be well known to you. The principal product is coke, made for a specific purpose. About 50 per cent of the gas made is used for heating the ovens, the other 50 per cent is available for other purposes. The tar oils obtained are very similar to those made in ordinary gas works practice. An extra amount of light oil is procured by stripping the gas of its saturated hydrocarbons.

Coke ovens fulfil a definite demand for a specific article, namely, hard coke for blast furnace working. The erection of coke ovens for the heat treatment of coal to give a supply of gas and tar oils to meet national needs is not practical. The hard coke is not a commercial product except for blast furnace and foundry purposes. It is not a satisfactory fuel for producers, and therefore the cycle of coal to the coke oven and coke to the producer and a mixed gas and tar oils to the community, is not attractive.

Undoubtedly there are big developments ahead for coke ovens. The surplus gas will be utilised and should certainly be supplied in bulk to

the nearest gas undertaking for distribution or to any neighbouring industrial concern requiring heat units. But improvements in working must be adopted, which will ensure an even quality of gas for distribution. At present the quality of gas from coke ovens varies too much. My personal belief is, that in the future gas, not coke, will be used to smelt iron ore. If this is so, coke ovens will be eliminated.

Gas Producers.—For many industrial purposes, such as steel manufacture, it is essential to have a large supply of heat units in the form of gas at a low cost. For this purpose, solid fuel is gasified in producers and a poor gas of about 110 to 130 B.T.U.'s obtained. Many types of gas producers will be well known to you. The great advantage of producers is that the capital cost is low, poor fuels can be used and high returns obtained by the recovery of the ammonia formed by the action of the steam in the producers on the nitrogen in the coal. I have never met anyone yet who really liked his producer plant. They fulfil a definite purpose, but they have moods. The great drawbacks to producer working, to my mind, are that the tar oils recovered are not valuable. The condition in which they come from the plant makes them difficult to work up and tar distillers tell me that the final products do not compare at all favourably in value with the final products from other methods of destructive distillation of coal.

Now that all fuel has gone up in price, and low grade fuels have risen in far greater measure than the higher grades, the economical advantages of the gas producer are not so pronounced.

Low Temperature Carbonisation.—For many years we have heard the cry against smoke in our cities. First, the deleterious effect of smoke on the human organism, vegetation and buildings; then the great waste of allowing all the valuable by-products of coal to go up our chimneys and be lost when they could be retained and used for the benefit of the Nation. A very proper cry! A very sound cry, and also a cry that has extracted millions of pounds from the pockets of the public! Low temperature carbonisation should on the face of it be a simple process. Many of the difficulties of high temperature working are absent, but other difficulties crop up and to such an extent that even after the tremendous amount of fine work that has been done and the enormous sums of money that have been expended, there is not one large commercial plant in successful operation to-day in this country.

Too much has been expected of low temperature carbonisation. The advantages are too obvious. It has been too easy to draft glowing prospectuses. The problem in reality is a most difficult one. Coal is difficult stuff to handle at any time. It is as variable in behaviour as woman, and will go its own way whatever pains you may take and however conciliatory you may be in your methods.

Caking coal at low temperatures swells and sticks. The solid residue is friable, and it is very difficult to get this sticky, friable mass to leave the vessel in which it is made. Many sincere attempts have been made to solve the problem. I do not believe it to be insoluble and for my purpose I propose to take it that a process is working satisfactorily.

The tar oils obtained are high in quantity and quality. The oils are in the best form for further utilisation and treatment. I believe that with such oils processes for further cracking will become as important in the tar oil as they are in the mineral oil industry. The gas contains considerable quantities of saturated hydrocarbons, which naturally are extracted and form a very valuable supply of light fuel oils. There is the resultant solid fuel. This at present is difficult to handle owing to its friability. Improved methods of manufacture will probably give a better commercial product. It will also be found possible to satisfactorily briquet this residue.

My objection is that we still have a solid fuel with the inherent disabilities set out earlier in this paper. Producers would satisfactorily convert this fuel into gas with the recovery of ammonia and this mixed gas would be distributed for industrial and domestic use.

Total Gasification Plants.—Immediately after the commencement of the War, I heard of a plant at work in Cologne which gasified the whole of the constituents of the coal, with the exception of the ash. Since the War, I have heard that the plant was not a success. In this country we have done better and a few plants which give only gas as a product are working here, whilst a large number of these plants are being erected.

The principle of this process is the partial carbonisation of coal in a vertical retort superimposed on a water gas generator, the retort being heated externally by means of the products of combustion of the producer during the blow period and internally by the passing of the water gas made, up through the charge in the retort. The plants are built in duplicate and the gaseous products are passed up one plant and down through the other for the purpose of "fixing" all hydrocarbons and retaining them as gas. It will be readily seen that a good total heat economy should be obtained and a large make of gas given on a small area, at a low capital cost, and with a minimum of labour. There are numerous difficulties to be overcome in order to obtain a plant which will gasify any kind of coal, not the least of which is the removal of clinker from the water-gas generator and the proper and even regulation of feed and flow of coal to and through the retorts above the producer. This process gives no tar oil and to my mind this is the great detraction to its national value. Another objection is that in "fixing" the gas the ammonia as well as the tar is destroyed.

The value of this form of plant to a small gasworks or as an adjunct to a large gasworks can be readily appreciated. The small gas manager would only have gas to sell, no coke, no tar to store, no sulphate of ammonia manufacture to superintend. In a large gasworks the production of coke could be regulated to meet the market and a plant capable of producing large quantities of gas at a low capital cost with a minimum of labour would be available.

An Ideal System.—After having thus very briefly reviewed the various processes for the heat treatment of coal, I venture to formulate a system of manufacture to meet the demand for liquid and gaseous fuels for practically all purposes. The total gasification of coal is essential, preferably in one vessel. The plant must be economical in first cost, and low in labour charges, but above all the maximum amount of the volatiles in the coal must be condensed and recovered in a liquid form, the distillation being carried out at such temperatures and in such a manner that a minimum of cracking takes place. The gas afterwards should be stripped of all saturated hydrocarbons and supplied to the consumer constant in heat value and specific gravity.

Further, special care must be taken to preserve the ammonia obtained from the nitrogen in the coal. The plant must be designed to work with any coal, but I do not believe it possible to design a plant of this type capable of working greatly varying coal over short periods, or of working coal containing, say, over 60 to 70 per cent of fines.

The form of plant I would suggest is one or more vertical retorts superimposed over a water-gas producer, the retorts being so constructed and heated that even difficult coals like Durham will work through without undue attention, and the coal fully converted into coke before entering the producer. The producer should be built and worked to obviate the formation of hard clinker, with mechanical grates for the continuous and clean removal of the ash. Automatic compensating devices would have to be included for the regulation of the pressure in the retorts during the run and blow periods. Such a plant, fitted with recuperators and waste heat boilers, would have a very efficient heat cycle, which would undoubtedly result in a large conservation of fuel. If the major portion of the coal used in this country were first treated by such a process, the fuel oil position would be made much easier, as greatly increased supplies would be forthcoming, the demand would accordingly greatly increase, and, as far as I can calculate, gas could be distributed to consumers at from one and a half times to twice the amount it would cost per heat unit to supply as solid fuel. The saving in labour and transport, the cleanliness, and the efficiency of utilisation would far more than compensate for this increased charge.

DISCUSSION.

The President, in moving that the very heartiest thanks of the Institution be accorded to the author for his valuable paper, said he thought all the members would regret that the difficult circumstances of the time had prevented Sir Arthur from dealing with what should have proved not the least valuable part of his paper, namely, some of the statistics which would have shown the relative quantities and values of the different products obtained from coal, because without those statistics it was difficult to gauge the situation as a whole. There was sufficient material in the paper, however, for the experts on retorting systems to carry on a very good discussion. The only difficulty he felt in connection with the paper was that he was not quite sure what the author did with his coke. If the author was going so largely to diminish the use of coke for blast furnace and other purposes, what kinds of coke was he going to get under his ideal system and what uses would they be put to? One great idea connected with the low temperature system had always been to obtain a fuel more or less suitable for domestic purposes, a point that had not been touched upon in the paper. Again, he was not quite sure that the author would get so near his ideal system as he suggested in putting his batteries of retorts right at the pit's mouth. Personally he thought there must be to some extent a centralisation of the processes. Then the whole question of transport needed consideration, because the author had to carry his solid fuel; he had to send his liquid fuel and his gas through pipes, and he had to get them to the centres at which they were required. He would like to know how far that was more economical in the matter of transport than taking the coal to the large centres where the different products would be needed.

Sir John Cadman, K.C.M.G., in seconding the motion, said he thought the Institution was very fortunate in having a paper from such an able exponent of the subject as the author. In the past there had been a tendency to discuss oil and coal on different platforms, and even to discuss the subject as "Oil *versus* Coal." He had felt for a long time that oil and coal as measures of energy should not be separated. The author had given a very interesting account of the various processes by which oil could be treated at a time when the country required to review its fuel resources on very definite scientific lines. He had indicated processes which were in operation and which he hoped might come into operation. The Chairman had also directed attention to the fact that it was necessary first of all to get the coal, an operation which at the present day was causing extreme anxiety.

He was led to wonder whether in reviewing the ideal conditions it was not desirable to go even a little further than Sir Arthur had done in his paper, whether they should not review the situation from that aspect of the case which was brought before their notice some years ago by Sir William Ramsay, when he suggested that the coal should be gasified *in situ*. At the time that was looked upon as rather an extravagant and unpractical proposition, but personally he was not at all sure whether the experiment suggested by Sir William Ramsay should not be given a trial. At the time it was put forward it was looked upon as an unpractical proposal, because of the difficulty of setting the coal underground on fire, but it was not entirely an unpractical proposal. He had had experience of mines in which the difficulty had been to keep the coal from being on fire. It was worthy of consideration whether, having in view the lines which the author had indicated, namely, the complete gasification of coal, methods of complete gasification of coal *in situ* could not be introduced. The subject was all the more impressed upon their notice in view of the extravagant labour difficulty in connection with the mining of coal, and he would like the author to give his opinion on the point. The petroleum industry had proved that drilling problems were very much simpler at the present time than they used to be in the past, and it would not be a difficult matter literally to riddle a coalfield with bore holes, and, instead of having colliery shafts with a great complement of underground workers, to introduce boring engines and to convert the pit-head frames into derricks. The Institution was to be congratulated on having had the paper read before it, because it was full of suggestions of the greatest importance. Before sitting down he desired to pay a tribute to the work that Sir Arthur did during the war. He happened to be in a position where he was able to see, particularly from the oil side, the great capabilities that the author brought to bear upon the subject, and time after time his sound judgment and his help in critical matters were such that the nation owed him a great debt for all the work he then did. He therefore desired to take the present opportunity of expressing publicly his appreciation—and the appreciation of all those who worked in connection with oil during the war—of the author's invaluable services.

Mr. Hackford said the paper had proved most interesting to him from the point of view of the future use of coal as a source of fuel oil supply for the Empire. The coal supply of the world at the present time was practically an estimate of its fuel requirements, and if it stood as 100 the fuel oil supply of the present day represented only 3 per cent. During the war everyone realised the value of oil as a fuel, and all wished to continue using the same, but failed to realise that

3 per cent of oil could not be made to do the work of 100 parts of coal. Even supposing very rich coals were distilled with a view of providing a liquid fuel substitute for the solid fuels of to-day, the amount to be distilled would be over five times our present output, even if the coal gave as much as 20 gall. of tar to the ton, i.e. an 8 per cent yield of oil. This general figure is also based upon the assumption that 1 ton of oil is equivalent in its heating properties to 2½ tons of coal. The question of national security and the cutting off of supplies of oil was indeed a very grave one. If coal was to be distilled with a view to obtaining oil to augment the supplies of the oil naturally found in Great Britain without introducing supplies from outside, it seemed to him every care must be taken only to use that class of apparatus which would supply the greatest amount of uncracked fuel oils. He used the term "uncracked" advisedly on account of the fact that, while engines existed, lubricating oils were needed, which came from natural petroleum oils after care in their manufacture had been taken. In making fuel oils from coal, a very satisfactory fuel oil, motor fuel, wax, and so on could be obtained, but the quantity of the lubricating oils produced from the coal distillates was very small, while the quality was poor. Consequently the country would always have to look outside for lubricating oil supplies, unless the natural resources of Great Britain could provide them.

Mr. Cunningham Craig said that in considering on a large scale the subject with which the paper dealt it was necessary to begin with general principles, and the author had dealt with them in a very clear and able manner, which had made it a great pleasure to listen to the paper. Several methods of treating coal had to be considered. First of all there was the method for making the greatest amount of oil of the best quality, the problem which the Petroleum Research Department had to deal with during the war. Then there was the method for making the greatest amount of gas of the best quality, which was a problem of the gasworks. Then there was the problem of making the greatest amount of pounds, shillings and pence out of the coal. That problem was taken up by the Cannel Coal Committee of the Society, and he was very pleased to see that in the general result the author had come very much to the same conclusion at which that Committee arrived a couple of years ago. The Committee did not deal with ordinary coal so much as with bastard coals, cannels and all kinds of colliery waste which were hardly considered as coal until the war forced them to burn everything that was black. The conclusion at which the Committee arrived was that low temperature carbonisation should be used to obtain not the maximum of oil but the best of the oil, and that the residues should be used in two alternative ways. If

the residues were high in ash the material should all go through gas producers and be completely gasified; but if they were low in ash they should be briquetted. The author had gone further and had plumped for complete gasification, but if that were general there would be great difficulty in getting enough oil and getting the oil of a really good quality. Another very interesting point made by the author was in respect to the attempts that had been made at low temperature carbonisation. Low temperature carbonisation was not being put into practice at the present time. It almost seemed as if fate was against it. It was a great pity that Sir George Beilby was not present to state what was being done at the Fuel Research Board station at Greenwich, which was started some time ago. He was sure that by now it must have tested every coal in the country, and be able to state exactly how each should be dealt with. It would be remembered that various attempts were also made during the war. Experiments were made at a gas works near Nottingham, and something like oil was made in vertical retorts; in fact, it was so like oil that he believed the Government offered a prize to anyone who would tell them what to mix it with in order to make it more like oil. Another unit was put up for low temperature carbonisation at a cost of, he believed, something like £35,000, but it was never operated and he believed it was sold for scrap; in fact, one almost began to think there was a hidden hand which stopped all the attempts, however well they started and however hopeful they might be. The Midland Coal Products Company, which was started as a result of the work of the Cannel Coal Committee of the Institution, fitted up an experimental station very efficiently and very cheaply through buying up scrap which was perhaps of greater value than it was supposed to be, but he had not yet heard that it had produced oil. However well the project started, however good the prospectus of the Company might be, or however good were the efforts of the people who dealt with the matter, there came a time when, as the Irishman said, the hidden hand stepped in, and the result was a fiasco, or at any rate nothing was done. The author had a great reputation for getting things done, and, now that he had so clearly put forward general principles with which everyone agreed, the members could only hope that the ideal conditions which made the best use of any coal would be realised some day. He desired to say as a geologist that it was rather a pity to speak about coal as if it was one kind of thing. There were so many different varieties of coal, some of which might be worth carbonising while others were not, if the idea was to obtain oil. The problem had to be studied in connection with each particular coal, particularly as the author had said he did not believe that any apparatus could be made to run continuously when different

material was put into it on different days. Another little criticism he desired to make was that, in spite of the difficulties of transport, it seemed to him it was better to have large stations for the carbonisation of coals, cannels and suchlike material, than to have a retorting plant at every colliery. That had been worked out very carefully. Some ten or twelve stations were specially selected for the treatment of thousands of tons of material from the point of view of the way in which transport could be most easily managed, but the scheme came to naught in the way that so many other Government schemes had done, and perhaps the least said about it now the better.

Mr. J. H. Anderson said that, with regard to the centralisation scheme that had been mentioned, he suggested that it was undesirable to particularise any individual as an electrical engineer or as a gas engineer. This lack of co-operation between specialised engineers had been the cause of the erection of some of the bad plants that at present existed, particularly the localisation of gas plants and power stations in isolated places where there was great difficulty in the transport of coal, and large stations for the gasification of coal and the production of power could be seen where the coal had to be carted to the place, showing a great lack of foresight in dealing with the problem of transport of the solid fuel. Some years ago he was very much interested in the question of the more scientific use of coal, and quite an interesting correspondence took place in *Engineering* in 1915 or 1916. At that time he suggested that the proper place for coal utilisation for power production, gas manufacture and by-product recovery for London was close to the Thames, where a copious supply of water for condensing purposes could be obtained and where the coal could be conveyed in modern ships and discharged by modern machinery right into the place where it could be gasified. In that way there would be a combination of the electrical engineer and the gas engineer, together with the chemist and other authorities, and thus the best would be obtained out of the material, including the recovery of the by-products lost from the present barbarous method of burning coal. The author had referred to the total gasification of coal. If total gasification of the coal took place, would any oil be obtained? The President had also referred to the necessity of catching the hare before it was jugged, and it was also necessary to catch the coal before it could be dealt with. It was a very curious thing that on the day on which such a paper was read a coal strike was proceeding. There was a very small output of coal per man in Great Britain compared with America, the British miner turning out something like only one-quarter of the output of the American miner, and also showing a gradual reduction even on that, while the American miner's output just as gradually increased.

If this country did not produce coal economically it would be thrown out of the world market altogether in coal production. Unless our miners produced coal in greater quantities to compete with the American miners, who produced nearly 1000 tons of coal per annum per man in comparison with 250 tons by the British miner, it was nearly time that the people of this country thought of something else whereby to increase the production of fuel, instead of talking about coal. That could only be done by thoroughly studying the subject. The English miner used no machinery, practically speaking, compared with the American miner. Eighteen hundredweights per man per day were turned out in Great Britain, whereas with one machine alone that the Americans used 30 tons per hour were turned out and loaded right away into the mine cars at the working face. Numerous other machines did the same thing. The coal was loaded into 4-ton wagons in the pits, and an electric haulage machine pulled the wagons out of the pits and dumped the coal on the top; probably our mine cars averaged about as many hundredweights. If the present situation was to be dealt with, it is necessary to deal more with the question of coal production. The miner must be taught that we depend on coal for the wealth of this country, and that if things go on as they are, the time will soon come when it will not be profitable to work our mines even for home supplies, let alone for the export whereby our country gets its main benefits from this material. His point in relation to this paper is even if it was the ideal system to gasify our coal at the mines, and recover all the liquid fuel at those places, the American mines would be in a similar position and would, with latest figures, be four times better off than us, thereby having more coal available for export and thus in a better position to wipe our export trade out entirely.

Dr. R. Lessing said that the author had a reputation for thoroughness, and he therefore appealed to him to publish the gist of the figures he had collected in connection with the various carbonising systems. Statistical material of that kind did not lend itself to use on such an occasion as the present one, but all those who were interested in the subject would welcome the benefit of the author's labours if he cared to place them on permanent record. If material of that type was published, information would be forthcoming which would indicate that considerably more liquid fuel was obtainable from coal than appeared from the present output. In regard to that matter a good deal was heard about a number of competing carbonising systems, in which it was also necessary to include types of producer gas and "Double Gas" working. It seemed to him the general mistake which had been made by the protagonists of the various systems was that one system wanted to oust the other system; that they were put in

competition one with the other; whereas there was plenty of room for all of them, provided they were efficient. He believed one of the main reasons for the failure so far of low temperature carbonisation was either that the low temperature carbonisers were always out to displace gasworks methods, coke oven methods, or producer methods, or that they maintained that they could use, and even tried to use, coals which were absolutely unsuited to their particular mode of working. If, on the other hand, only fuel suited to the particular purpose in view was used, a very different result would be obtained. Even in the comparatively narrow field of continuous vertical retort working, the author had stated that one particular make of retort was not suited to every type of coal. Possibly it was suited to only one or two of them. How therefore was it possible, with systems of a widely varying character and widely varying method of treatment, to deal with the different varieties of coal? It was absolutely impossible from an engineering point of view. The type of liquid fuel that was being obtained from coal had been subjected to a very scant amount of research or practical work. We were at the present time getting coal tar as it was obtained by Clegg in his works a century ago. The form and constitution of that coal tar had been cleared up very little during the last forty years. The same state of knowledge existed with regard to it as in the early days of the aniline dye industry. All the research on coal tar that had ever taken place had been done on only about 5 per cent of its constituents, which were used for aniline dye making. The remaining 95 per cent of coal tar constituents was practically an unknown field. Whatever went into the fuel oils, the creosote and the anthracene oils were a closed book to them at the present day. He submitted that research on that part of the liquid fuel production which was available should be translated into commercial practice without much further delay. Tar distillers were just as much to be blamed for the existing state of affairs as the colliery owners or other fuel wasters. There had been very little progress made in connection with tar distillation during the last fifty years. A few small details had been improved, but the principle adopted was still the same as in the early days. In such an Institution, where many men were familiar with modern methods of distillation, some of the methods which were being used at the present time in tar distilleries would simply rouse a feeling of ridicule. One of the great difficulties in connection with tar distillation was that even if tar had been got under the best conditions of coal carbonisation, i.e. at the lowest possible temperature in the coal retort and coke oven, the tar distiller passed it again through temperatures most favourable to its thermal decomposition and catalytic dehydrogenation. Research in that direction was urgently required. He had worked out a

process, and one plant was put up by the Admiralty during the war for separating the pitch from the oil without the medium of distillation, and the experience obtained seemed to point in the direction that it was necessary to get rid of the pitch first, when the maximum amount of liquid fuel is obtained. This can then be submitted to distillation in the ordinary way with a great saving in time, fuel, still space, renewal of still bottoms, and a better chemical control of process and products.

Mr. Braithwaite said that one or two of the speakers, including Mr. Cunningham Craig, had expressed impatience at the slowness in evolving some method of retorting coal whereby the maximum by-products were obtained. The reproach with regard to the hidden hand to which Mr. Cunningham Craig referred applied not only to England but to other countries. He knew that the Germans, the Belgians and the Americans, in addition to English people, had been dealing with the subject for years, and he did not think one of them had even scratched the ground yet. Certainly none of them had made a success of anything. The question was how success was to be obtained. There were hundreds of inventions and hundreds of inventors, but the creations of the inventors had not got beyond paper in most cases. A few retorts had been put up in England, but the number of its low temperature carbonisation retorts could be counted on the fingers of one hand. There were a few in Germany, but a commercially successful method of obtaining by-products from caking coal had not yet been evolved in either country. The inventor who planned such retorts was generally a person without much means, and nine times out of ten he had no market for them. People looked at them and funked them as a general rule, and some people who were brave enough to try them did not seem to have made them a success. The only way in which to obtain success was by means of experimental stations, at which as many different kinds of retorts as possible should be tried. If patriotic members of the community or a wealthy and generous Government would provide a few more stations of this kind where such inventions could be tested in actual working and their defects discovered and eliminated, then some definite progress might be made. Hitherto this industry had not had a chance, having been largely dependent for its existence on share-pushing organisations. If Sir Arthur Duckham's paper had the result of impressing upon this country the enormous importance of the subject, and inducing the community to erect more and more retorts until something could be found capable of recovering the by-products from all kinds of coal on a commercial scale, then we might congratulate ourselves that this evening had not been spent in vain.

Mr. Reilly said it would be interesting to know, in connection with what had been said about low temperature carbonisation and high temperature carbonisation, where one ended and the other began. A good deal has been heard in the past of the products of low temperature carbonisation, such as carbo, coalite and various other things that were supposed to be the product of low temperature carbonisation, and it was also well known that there were such things as soft coke and hard coke. The author referred in the course of his paper to the question of the total gasification of coal, to the steaming of retorts, and to the by-products and oil that came out of the coal after the steaming process had taken place. This is not in accordance with practice; usually the steaming of coals in retorts prevents entirely the yield of oil. He had in mind a little plant that was worked some years ago, known as the Delwick-Fleicher plant, which was capable of making only blue water gas. The principle was that, by making ordinary coal gas at a low temperature, a large quantity of rich gas, in the neighbourhood of about 9000 ft. to a ton of coal, would be produced. The process was to turn out something like 18,000 ft. of blue water gas and to mix it with the very luminous gas in order that the mixture when diluted would be a saleable product and would fulfil the requirements of the statutory regulations at that period. What happened in connection with the mixing of the blue gas and the rich illuminating gas was that the whole of the oily products, particularly the benzol fraction, were removed from the coal gas to mix with the diluted mixture which was sent out from the gasworks to be burned in the ordinary burners. It was also found that there was no benzol to be condensed from the tar resulting from the steaming process after the tar distiller got it. He bought his tar at so much a gallon and came back to the gasworks and said the tar contained no benzol. That was a point that must be borne in mind in connection with the supply of oil that came from coal, if an attempt was going to be made to get it both ways. He would be glad to have an opportunity of inspecting the figures to which the author had referred, and would be very glad if Sir Arthur would let him know at what time it would be possible for him to see them.

Lieut.-Col. R. H. F. Standen said that he had been interested in low temperature carbonisation for five or six years, and he desired to tell the author that a retort was actually in operation in the Midlands in which all classes of coal have been successfully carbonised at low temperature. The time of coking was about 2½ hours, and the coke is not friable, nor does it stick to the retort. He had risen to speak because of Sir John Cadman's very interesting suggestion that a borehole should be put down in a coalfield, and, as far as he could make

out, a match dropped into it, so that gas would then be obtained. He happened to be one of those terrible people, a coal owner. On his land there was 34 ft. of good volatile coal; he was six miles away from any pit, and if anybody would like to do some experimenting he would be very pleased to offer his little property—on terms.

Mr. Gordon Pitt said the suggestion had been made that it was inadvisable to carry out the treatment, whatever it might be, low temperature or high temperature carbonisation, at the pit head. In his view a good deal of the inertia that was apparent on the surface in the development of suitable methods of coal carbonisation was due to the fact that carbonisation had been distributed all over the country and was in the hands of so many different people, who could not rely on constant supplies of the same class of coal. It was therefore hardly worth their while to make accurate technological observations. Tar distillers could not always get the same class of tar and tar oils as there was an enormous diversity amongst tars obtained from different coals. On the other hand, if the author's suggestion were carried out and plant was put up by each particular colliery or in each particular colliery district where the class of coal would remain more or less constant, close research would be possible, and, more important still, close control of the ideal conditions under which that coal could be treated. That would be a much simpler plan than any method of distributing coals from various collieries to central plants. With regard to the question of transport, he would be inclined, as an engineer with some experience, to say that, starting *ab initio*, the distribution of any given number of millions of thermal units of heat or heat equivalents would be simpler if the vehicle of the heat were in gas and in liquid than if it were in solid.

Mr. George Howell thought there could be no doubt that if it was possible to treat coal as one of the future sources of fuel oil something of very great national importance would have been accomplished. He desired in that connection to ask the author a question. The success of the by-products installations of the Australian Gas Light Company in Sydney has been an economic fact worthy of note. This Company recovers large quantities of ammonia sulphate, benzol, liquid fuel, motor spirit, toluene, solvent naphtha, naphthalene and pyridene. Some of the oils obtained by distillation are sold for liquid fuel, and others are disposed of to manufacturing concerns. The plant cost £40,000 and at present it treats only 200,000 tons of the 400,000 tons of coal used annually, but, nevertheless, the revenue produced from the by-products is about £140,000 a year. The by-products actually recovered from these 200,000 tons can be enumerated, namely: 30,000 gallons of benzine and toluene, for conversion

into motor spirit; 150,000 gallons of oils for disinfectant purposes; 30 tons of crude naphthalene; and 400,000 to 500,000 gallons of liquid fuel. The question he desired to ask was: If the coal was treated entirely for the production of oils instead of for gas-making what percentages of those various oils would be obtained?

Dr. Ormandy said he desired to express his pleasure at the fact that an authority on coal had been induced to speak at a meeting of the members of the Institution of Petroleum Technologists. As a member of the Council he had urged for a considerable time—in fact, ever since he first came in contact with Sir Boverton Redwood in connection with the Institution—that it should be an Institution to deal with the subject of petroleum interpreted in the very widest terms. It was discovered, on looking into the archives of the Institution, that the word "petroleum" meant anything which was derived from a mineral, and, as coal might be regarded as a mineral, the oils which came from it might also be regarded as coming within the purview of the Institution. It seemed to him undesirable that subjects in connection with which oil was of primary importance should be discussed sometimes at the Institution of Gas Engineers and sometimes at other Institutions, when there was one Institution which was particularly devoted to petroleum and oils in general when produced from minerals. He hoped the paper would be the first of a considerable series, so that the knowledge of the members of the Institution might be widened, because petroleum people could derive nothing but gain from what they learned from coal people, and *vice versa*.

The resolution of thanks was then put and carried unanimously.

Sir Arthur Duckham, in reply, said he thought the President misunderstood what had been written in the paper when he asked the question, What would happen to the solid fuel from the total gasification plant? As a matter of fact, there would be none. The question had also been asked how oils would be obtained if the coal was totally gasified. He had tried to make it clear that in total gasification the greatest amount of volatile products in the form of oil would be recovered from the coal, by the ordinary methods of carbonisation, before the gasification of the coke residue commenced. Total gasification simply meant that there would be no solid residue left. With regard to Sir John Cadman's remarks, personally he had always been a great admirer of Sir William Ramsay, whom he knew well, his brother being one of Sir William's pupils. When he first read, in the *Westminster Gazette* he thought it was, Sir William Ramsay's idea of putting a pipe down into the ground and gasifying the coal

underground, it struck him as an engineer as being a very formidable operation. As a man with a very great respect for coal, its behaviour under heat treatment and its nasty tricks and habits, he could not see the physical possibility of carrying out the idea. He could quite well see that if a solvent of some sort was used and sent down the pipe, thus dissolving the coal, the product could be pumped up. That would be an excellent idea. But he looked at the problem in the following way. There was a great mass of coal into which presumably air, or air and steam mixed, was put to make it burn, but that coal must be consumed in a strata and that meant the production of clinker. As the mass of coal in the strata was consumed, the roof would fall in and thus shut the door. The door would be built up in the strata against the inlet of air or air and steam, which he supposed would come down the same pipe as that which the gas went up. He did not see how it was possible to get over the difficulty of the fall of the roof and the formation of clinker, looking at it from a practical point of view. Of course one would like to be able to do it. An easy way to do it might be to put the carbonising plant at the bottom of the pit, but in his opinion the best solution was to put a solvent down. It was impossible to lay down any definite rule for the treatment of coal, there being so many variables. First of all there was the great financial variable of what was the thing that paid a man best; but he thought plants could be so devised that there was a great deal of latitude on working, so that the variables might be changed. In South Africa, for instance, there was a tremendous field for the development of oil production from coal, quite independently of the provision of heat units from the coal, either in a solid or in a gaseous state. There was no oil found in South Africa, and oil fetched a very high price there. Transport was almost impossible for solid fuel from many of the pits. If it was possible to introduce the low temperature treatment of coal in South Africa, there was a good prospect of a sound financial return from such a process. He had made experiments with the various coals and had recently obtained 30 gallons of tar and 2000 cubic feet of gas per ton of coal carbonised at a very low temperature. That was a process specially adapted to South Africa which would be of no use in a normal way in this country, where the value of the residual solid fuel would be lost to a certain extent. With such treatment it might be possible to obtain, at those low temperatures of working, lubricating oils from the coal; but he was not a technician and was therefore not able to give many details. The suggestion of a station on the Thames was a good one, provided the coal could be brought to the Thames and treated there more cheaply than at Nottingham or any other coalfield. It was a matter of balance.

Although he had in his paper dogmatically in a way laid down certain lines, he had only done so in order to promote discussion. All the statements were capable of qualification, and he had given a certain broad line which could either be adopted or rejected. With regard to the American practice of raising coal, it must be remembered that the Americans were working on big faces under entirely different conditions from those that existed in England. On the Coal Commission he got rather tired of American practice *v.* English practice on the coalfields. Mr. Reilly had referred to high and low temperature carbonisation. He was not a critic of low temperature carbonisation *qua* low temperature carbonisation. He thought there was a future for it, but the problem was very much more difficult than had been stated. It was very difficult to say where high and low temperature began and left off. He would like to see in writing Mr. Howell's question with regard to the Sydney gasworks. That was really a low temperature plant, because it was a continuously working vertical retort with low temperature round the top of the retort, so that the coal came into a vessel, was gradually heated at a low temperature which was gradually increased. It was really a fractional distillation of the coal. In that case the products were low temperature products more or less. He thought some of the results that had been read out tended to show that in a continuously working vertical retort there was a low temperature process combined with a high temperature process, because of the frequent changes from the low temperature to the high temperature as the coal mass heated. It was impossible to say which was which in a vertical retort. The steaming rendered it more like a low temperature process. In the horizontal retort the charge was put in for four, six, eight, or twelve hours. That was a high temperature process, because the whole retort was heated highly outside and the gases coming over usually had to pass over a space before they got out. The more one filled a horizontal retort the more one approximated to low temperature working, because the vapours were not cracked on leaving the retort. He did not know whether he had heard Mr. Reilly correctly, but he understood him to say that 18,000 feet per ton of coke were made on the Delwick-Fleicher apparatus.

Mr. Reilly said that was so.

Sir Arthur Duckham said that seemed a low figure. With regard to the cycle of operations, the important point that had to be borne in mind was that the most valuable way of getting heat units for the use of the community was in their liquid form. Therefore heat units were worth more in a liquid form than in any other form, and it behoved them to get heat units in a liquid form to the greatest possible extent. After that heat units were worth more in their gaseous form. The

two most valuable forms of heat units from coal were, firstly, liquid units, i.e. the lowest possible temperature of carbonisation, and secondly, gaseous fuel, which could be used far more economically and with far less labour for many purposes than solid fuel.

The meeting then terminated.

The Fiftieth General Meeting of the Institution was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C. 2, on Tuesday, 23rd November, 1920, Sir Frederick W. Black, K.C.B. (President), occupying the Chair.

The Members of Council present were Messrs. H. Barringer, E. H. Cunningham-Craig, Arthur W. Eastlake, James Kewley, Dr. W. R. Ormandy and Mr. T. C. Palmer.

The following papers were read :—

The Lamp Method for Estimating Sulphur in Benzine.

Note on a Modified Form of Apparatus.

By J. S. Jackson and A. W. Richardson.

The estimation of the sulphur content of various motor spirits presents numerous problems which have interested us for some time past. In using the Esling Apparatus we became conscious of certain features which, in our opinion, were not very satisfactory. These may be summarised as follows :

1. It is, we think, generally recognised that sulphur is held up in the wick, necessitating a fairly lengthy operation for its recovery.
2. In order to get a non-smoky flame only a small quantity of spirit can be used (about 0·5 grm.).
3. The process is very lengthy and the volumetric estimation is hardly satisfactory.
4. A very steady suction must be maintained if difficulties with the flame are to be avoided.

Our work has therefore been directed towards the elimination of these difficulties, and we trust that although the work is by no means complete, the results already achieved may be of some interest.

In the first place the cotton wick has been replaced by a bundle of capillaries, sufficient air being injected into the apparatus to enable undiluted spirit to be burnt with a non-luminous flame. In this way large quantities can be very quickly burnt (about 5 grm. in 1½ hours) without any difficulties arising from smokiness or control of suction.

The development of this idea is of some interest. In the first instance air was bubbled through the spirit. This process is open to the objection that fractionation would take place. If, however, there is a slight depression in the bottom of the lamp it is found possible to empty the lamp completely and therefore the question of fractionation does not arise. In the case of the less volatile spirits it may be necessary either to supply heated air or to warm the lamp by standing it in warm water or on a hot plate.

The lamp is finally washed once or twice by burning through with a little sulphur-free benzine of which supplies can readily be obtained or prepared.

We then conceived the idea of spreading the capillaries by means of a central air tube which is lightly jammed into position. By this arrangement the air does not pass through the benzine, so that fractionation is greatly reduced if not eliminated. The current of air escaping from the top of this air tube produces a slight reduction in pressure which assists the capillaries, and enables them to supply sufficient benzine to maintain a strong non-luminous flame.

In both lamps a mixing chamber is provided above the tops of the capillaries, and the luminosity and size of the flame are easily controlled by the air supply.

The obvious advantages of this type of lamp are :

(*a*) The capillaries can easily be taken out, washed and any sulphur held thereon oxidised and included in the estimation. Experiments have shown, however, that the quantities so obtained were negligible.

(*b*) The flame is hotter, and therefore the probability of complete combustion is greater. In view of the difficulty of getting glass which will stand the heat of this flame we suggest protecting the top of the tube by a silica jet.

(*c*) Much larger quantities of spirit can be burnt in a comparatively short time, thus assuring greater accuracy.

This work is not complete, nor do we suggest that the diagrams shown indicate the final form of the lamp. We have merely used the apparatus at our disposal to demonstrate that this idea will work. We hope to be able to show a lamp in the near future with all the advantages and none of the defects of those already described.

DISCUSSION.

Dr. Thole congratulated the authors on the production of a very ingenious carburettor, and enquired if it could be used to burn heavy grades of benzine and kerosenes. The usual form of lamp, burning

with a cotton wick a hydrocarbon oil diluted with alcohol or amy
acetate, was equally effective with a light benzine or a heavy kerosen
Whichever form of lamp was used, he considered it necessary to bur
the sample down to dryness (finally "rinsing" the apparatus with
further quantity of a sulphur-free combustible) in order to avoid frac
tionation, resulting from either selective evaporation or selectiv
absorption by the wick of particular components of the sample unde
test.

He also asked if the authors had found this form of lamp effectiv
in burning the sulphur compounds in coal tar benzol. His ow
experience had been that although the lamp method gave results o
high accuracy with the lighter products from petroleum, carbo
bisulphide and thiophen could be completely burned only with con-
siderable difficulty, and most chemists preferred to employ heated
platinum gauze to ensure complete oxidation when burning benzols.

Dr. Ormandy said the subject was of very great interest to the
National Benzol Association at the present moment, when the motor-
car user was under the impression that he was liable to suffer if there
was more than a certain small amount of sulphur in the benzine which
burned in his motor-car. Personally he thought his fears were very
much exaggerated. In order to find out if it really was a serious
problem, a friend of his during the war wanted to run with benzine or
petrol, but he could get neither of them from a careful Government.
The Government said to him: "You own a tar distillery and you
produce a lot of fore-runnings; they are of no use to us, so you may
burn them." Having nothing better, and living a long way from his
works, he burned a mixture of 50 per cent of carbon bisulphide and
50 per cent benzol, and he ran a four-cylinder Delage with no detri-
ment to the engine in question. Nevertheless, as long as the fears to
which he had referred existed it was desirable that one should be able
to estimate the sulphur accurately, because the materials were required
for other purposes than driving engines. The subject had been occupy-
ing the attention of the British Engineering Standards Association,
and he had the misfortune to be a member of a Committee of that
Association which sat occasionally and which had been carrying out
experimental work in relation to the determination of sulphur in
benzol and petrol. The Committee had not yet come to a conclusion
as to the most rapid, convenient and accurate method for estimating
sulphur. He believed that the final meetings of the Committee of the
British Engineering Standards Association would be held during the
following week, and that the full details of the standardised method
which had been adopted by the Association, in conjunction with the
Tar Trades Association and the National Benzol Association, would be

published shortly thereafter. He had no personal experience of the lamp method, but he thought it might be of interest to the members to know that there was another method for dealing with the same subject which had been the subject of very careful consideration and a good deal of experimental work.

Mr. Anfilogoff said it was very interesting to notice that a lamp had been produced in which the wick had been done away with, but a huge amount of air, comparatively speaking, would be required in order to aerate the petrol in the bottle to enable it to burn, whether it was passed through that or whether it used the capillary tube, as shown by the authors. It would be rather interesting to know how the authors kept their air free from sulphur. Would not that add to the percentage of sulphur in the test than otherwise ?

Mr. J. E. Hackford said that the idea of being able to vaporise oil by other means than passing air through it for the determination of sulphur was one to which a great deal of importance was attached. At the present time the frequent use of casing-head gasoline, especially in the United States, gives a mixture which does not always boil in the form of a continuous curve. The casing-head gasoline vaporised first, and, in some circumstances, when attempts were made to estimate the sulphur by the wick method, or by the bubbling of air through the gasoline itself, fractionation undoubtedly took place. The method of vaporising by means of capillary attraction seemed to open a field which would enable chemists to conduct sulphur determinations with a great degree of accuracy. The apparatus was ingenious and simple, and the authors and their assistants were heartily to be congratulated on its production.

Mr. Reilly said he desired to refer to one point in connection with the author's ingenious lamp and the arrangement of the capillary attraction tubes. He understood from the author's paper that the upper portion of the tube burned out owing to the intense heat created by the flame. In the Gas Referee's sulphur test, which had been used for the past quarter of a century in connection with the estimation of sulphur in coal gas, a great deal of trouble was found prior to the introduction of the ordinary steatite burner tip. He wished to ask the author if it had occurred to him to fix a steatite tube on the uppermost part of the capillary tube in order that the danger to which reference had been made might be eliminated. It seemed to him a very much better method of gasifying petrol by drawing it up through capillary tubes and burning it off with a complete atmospheric flame, than the wick method, more especially as the sulphur could be estimated in the ordinary way.

Mr. Evans enquired whether the author had any experience of

burning lubricating and heavy oils in the modified apparatus. He would also like to ask Dr. Ormandy whether sulphur could be estimated at all in lubricating oils with the apparatus to which he had referred.

Dr. Ormandy said the apparatus to which he had referred was designed entirely for the estimation of sulphur in motor benzol.

Mr. McConnell Sanders said that Dr. Thole had raised a point upon which he might be able to give a little information, as he had once had the opportunity of thoroughly investigating the matter referred to.

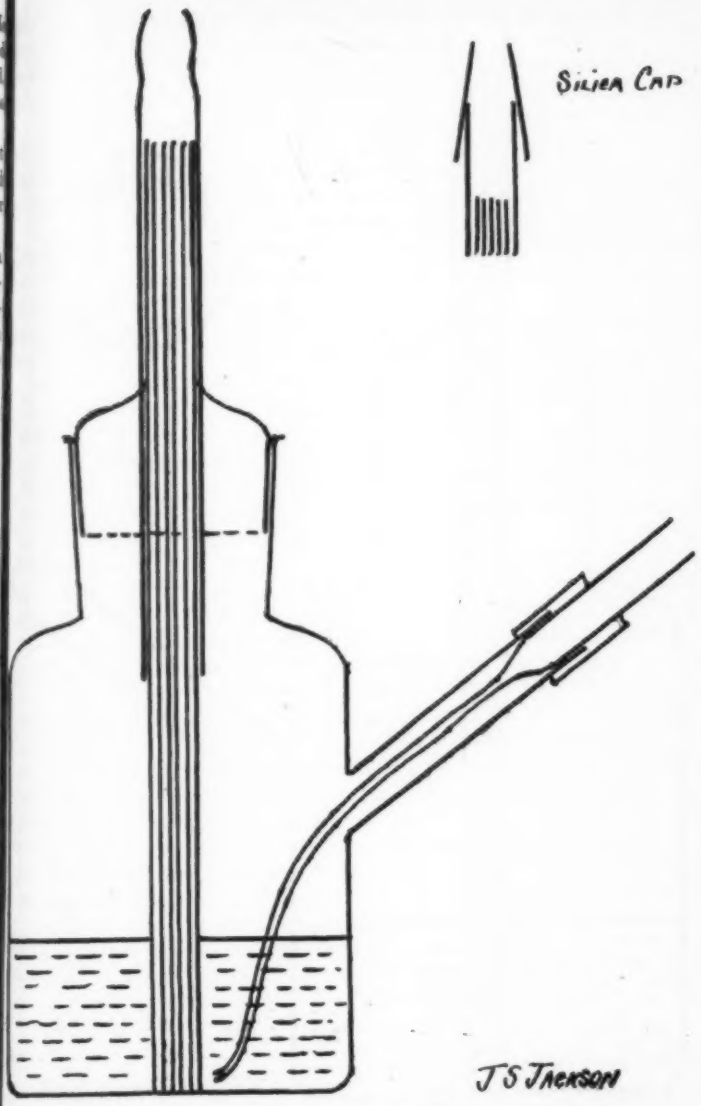
When he first came in contact with the present lamp method, which is only a recent development of the original Engler method, as improved by Heusler, Ohlmüller, Kiessling, Schulz and others, he discovered that sulphur seemed to be retained by the wick. Conradson also pointed this out in 1912, and stated that the wick, after the lamp test, should be burnt in order to estimate the contained sulphur.

He attributed the concentration of sulphur in the wick to the presence of sulphonates formed during the refining treatment. In the course of experiments with oil which he (Mr. Sanders) knew to be free from such compounds, he still found that sulphur was retained by the wick.

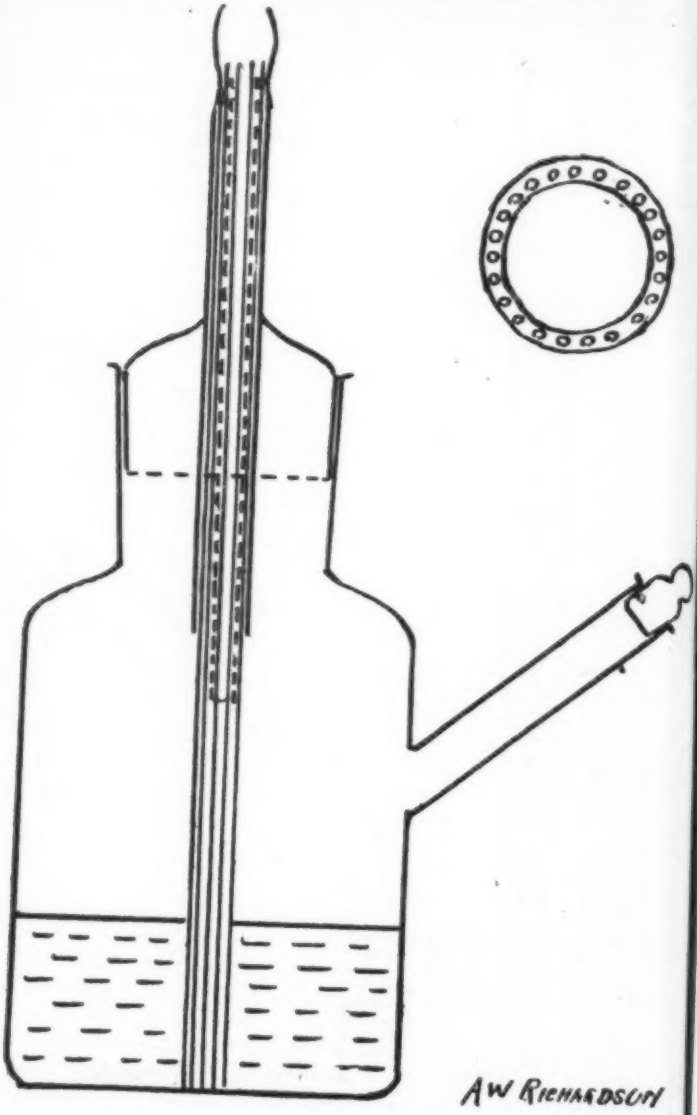
It then occurred to him that possibly the rather large wick of the Engler lamp, and the six or eight-strand wick of the Schulz lamp, which was very much like Mr. Esling's, might be acting much in the same way as fuller's earth did in absorbing sulphur compounds, and he was able to prove this in the course of some very extended experiments.

Briefly the method was as follows: Using the form of apparatus as commonly sold in the United States some six or seven years ago under the name of "Sulphur-testing apparatus," which differs from that described by Mr. Esling only in the shape of the lamp and the use of glass beads instead of glass wool for breaking up the gaseous combustion products, he determined by the bomb method the total distribution of sulphur in the system during the lamp test, i.e. the total sulphur in the oil, that in the products of combustion, in the oil retained by the wick, in the wick itself, and in the residue. If the normal sulphur content of the oil was not disturbed by the lamp method, its distribution in the system should be uniform throughout, and the sulphur content per cent should be the same for the oil burnt, that retained by the wick, and that left as a residue in the lamp. That was found not to be the case; there was a definite concentration of sulphur in the oil retained by the wick and in the residue.

That raised the question of possible selective absorption which was put to the test by taking a large quantity of purified cotton wick, putting it in a tube, passing kerosene through it and determining the



JACKSON AND RICHARDSON'S SULPHUR ESTIMATION LAMP.



JACKSON AND RICHARDSON'S SULPHUR ESTIMATION LAMP.

sulphur percentage by the bomb method before and afterwards. Again it was found that the wick most certainly did retain sulphur. Bringing it to a practical issue, it seemed to him that the large wick of the Engler apparatus and the comparatively large one of the Schulz lamp were disadvantageous, and a new lamp was devised in which the wick holder was practically a capillary, and a single strand of cotton was used as a wick. This reduced the error considerably. With a six-strand wick in the Shulz lamp it was found that about 0·5 per cent of the total sulphur in the oil, when burning 4 grams, was retained by the wick; with a single-strand wick this was reduced to 0·04 per cent.

It was necessary to point out that a great deal depended upon the quality of the oil and of the wick.

Mr. Anfilogoff had referred to the question of the purity of the air in the laboratory when the lamp method was used, That was a great problem to him in Mexico, but he was able to devise a special form of lamp-holder in which the lamp chimney rested in a seal of mercury. Air was brought up through a purifier underneath the lamp and diffused through gauze after previously passing through filters of glass wool soaked in ordinary litharge solution and sulphuric acid. The latter was necessary because not only sulphur compounds in the air but also ammonia had an effect on the test.

A further difficulty arose in that the methyl-orange indicator which was used for the titration was not sufficiently sensitive, and when starting a test it frequently happened with some kinds of oil that it was impossible to prevent a certain amount of smoking, which although very small was sufficient to alter the yellow tinge of the indicator.

It was therefore felt that a more sensitive indicator would be an advantage, and for the last four or five years he had consistently used methyl-red for the purpose. It was much more sensitive than methyl-orange but possessed an apparent disadvantage, namely, that it was sensitive to carbon dioxide. This character was taken advantage of, however, for procuring a sharper end-point in the following way: The titration was performed in the U-tube itself; towards the end of the titration the solution was usually pink from the liberated carbon dioxide reacting acid to the indicator. On bubbling air through it, just in the same way as when burning the lamp, the carbon dioxide was removed and the solution regained its yellow colour. It was very easy to repeat the addition of acid and subsequent air bubbling in such a way that a single drop of acid completed the titration sharply, and it was a very much easier indicator to use and more "fool-proof" than methyl-orange, especially in refinery practice where a very large number of determinations were a matter of daily routine.

The Authors, in reply to the points raised during the discussion,

state that the lamp works quite satisfactorily with benzol, but they have not yet succeeded in using it with kerosene.

The question of the purity of the air supply had not escaped their attention, and precautions were taken to ensure the purity of the air supplied to the lamp. The whole apparatus was enclosed in a suitable case to which only pure air was admitted.

They would like to emphasise the fact that the increased speed of burning makes the estimation much more convenient, and more independent of external influences.

Finally they suggest that more satisfactory results are obtained if the sulphur is estimated gravimetrically when the "lamp" method is employed.

The Laboratory Testing of Oil Shale for Oil and Ammonia Yield.

By E. Lawson Lomax, M.Sc., A.I.C., F.C.S., and F. G. P. Remfry, B.A., D.Sc., A.I.C., F.C.S.

1. Sampling of the Shale.

Like many other materials composing the earth's crust, oil shales become altered by exposure to weathering conditions, and therefore, when taking samples at an outcrop, it is advisable to dig in at least 10 ft. from the surface.

The face of the working should then be trued up from floor to roof, and two parallel lines, about 9 in. apart, drawn vertically through the whole face of the seam. By cutting away the shale on each side of these lines to a depth of 6 to 9 in. a rectangular pillar is left, which is marked off in lengths of 6 in., or at such points where any definite change in structure is noticeable.

Starting nearest the roof, the pillar is cut horizontally at the first mark, and the block of shale detached from the face, and so on downwards, each portion being measured vertically before removal from its position, and afterwards numbered and bagged, or better still, put in biscuit tins, in order to minimise loss of moisture as far as possible.

A useful form of instrument for cutting samples is in the form of a pick, but instead of points, having an axe at one end and an adze at the other.

2. Preparing Samples for Analysis.

All samples should be analysed as soon as possible after being taken, since alterations take place on exposure to air, for which reason they should not be removed from their tins until required for analysis.

The whole sample is first broken up into pieces about the size of a small walnut, well mixed and quartered, to get a fair sample of about 1500 grm. This is again quartered down to obtain (1) 100 grm. for moisture estimation; (2) 100 grm. for total water; (3) 100 grm. for ammonia; (4) 10 grm. for total nitrogen, total volatile and fixed carbon; (5) 1000 grm. for oil yield estimation.

In our opinion it is best to start in every case with the shale in the state it came from the mine, for in practice this will probably be the condition in which it goes into the retorts.

It is only in special cases, such as comparison on the same shale of different methods of retorting, that the calculation should be based on theoretically dry shale, for under such conditions the action of the retort on the "kerogen" alone is what is being determined.

Proximate Analysis.—This includes total and hygroscopic moisture, volatile organic matter, fixed carbon and ash.

Moisture.—

(1) *Hygroscopic Water.*—Determined by heating finely ground sample to constant weight in water oven.

(2) *Total Water.*—Retorting 100 grm. of shale without the use of steam, precautions being taken to condense all water vapours. Difference between percentages obtained in 1 and 2 gives water of combination.

Volatile Organic Matter.—If a platinum crucible is available we employ the method recommended by the Committee on Coal Analysis of the American Chemical Society and published in the Journal of the Society for 1889, 21, 1116. It is as follows:—

Place 1 grm. of pure bitumen in a platinum crucible weighing 20 to 30 grm. and having a tightly fitting cover. Heat over the full flame of a Bunsen burner for seven minutes. The crucible should be supported on a platinum triangle with the bottom 6 to 8 cm. above the top of the burner. The flame should be fully 20 cm. high when burning free, and the determination should be made in a place free from draughts. The upper surface of the cover should burn clear, but the under surface should remain covered with carbon.

In the absence of a platinum crucible, we recommend the following method, which gives satisfactory results:—

One grm. of the finely ground and dried shale is placed in the bottom of a porcelain or silica crucible, which is then filled to the brim with dry, previously ignited sand. The crucible is then heated over a Bunsen flame till fumes cease to be evolved, the covering of sand preventing access of air and thus rendering the use of a tight-fitting lid unnecessary. When, however, carbonates are present in the shale, it is hardly necessary to say that these results will always be high, and

special precautions must therefore be taken, and it should also be noted that combined water is included in the losses recorded by these methods.

Volatile organic matter may also be roughly determined when estimating total water by method given before; the difference in weight between the residue in the retort and original weight of shale less water equals volatile matter.

3. Fixed Carbon.

(1) *Direct Determination.*—This determination is made by igniting the residue in the platinum crucible with lid off, to constant weight. Loss of weight equals fixed carbon.

(2) A portion of the residue from retorting for water and volatile organic matter may be ignited in a silica crucible in the same manner.

(3) One grm. of the original dried and ground shale is ignited to constant weight in a silica or porcelain crucible. Total loss equals water and volatile organic matter and fixed carbon, from which the percentage of the latter is calculated.

The previous note as to the presence of carbonates applies also in these determinations.

The authors wish strongly to emphasise the fact that crucible methods are only suitable for the estimation of fixed carbon and ash, and that any reports made regarding the quantity of oil contained in any shale determined by such methods are absolutely fallacious, and not worthy of consideration.

Retorting of the Shale.

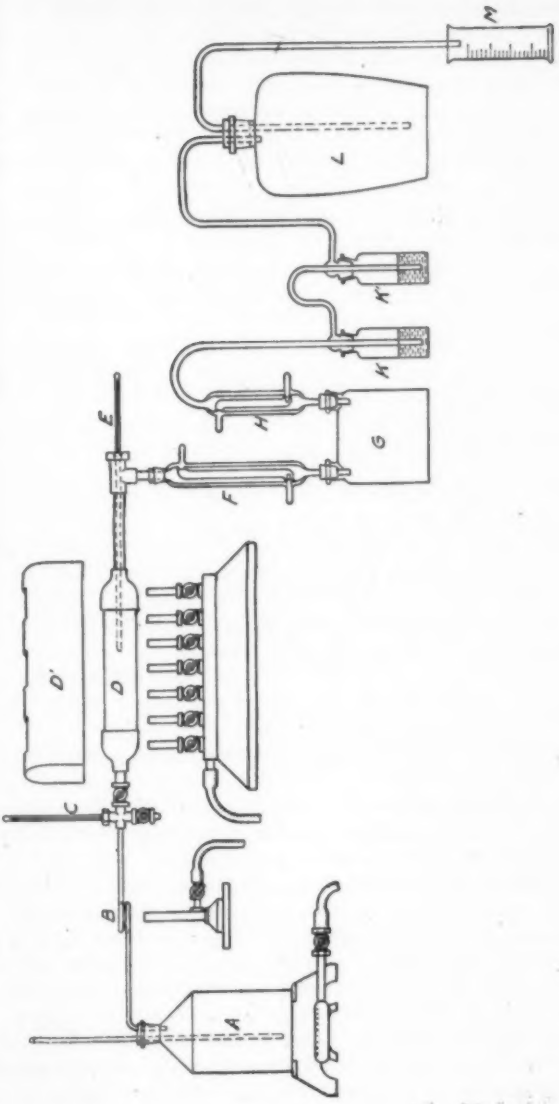
Retorting with Steam.—The apparatus we recommend for this purpose is shown in the accompanying sketch. It consists of:—

A. A steam generator, conveniently made from an ordinary 1 gall. oil can.

B. A superheater, a single coil of $\frac{1}{4}$-in. gas pipe.

C. A cross union, which is used for a thermometer fitting, pressure regulator and drain, connected to the retort D through a steam valve.

D. Retort (1) for oil yield, consists of 20-in. length of 3-in. iron pipe, fitted at the inlet end with a 3-in.$\times\frac{1}{4}$-in. reducing socket, and at the exit end with one of 3-in.$\times\frac{3}{4}$-in. To the latter is adapted a Tee union, of which the horizontal opening can be closed by a plug, or used as a socket for thermometer E, to determine the temperature in the retort. Such a retort will hold 1000 grm. of shale.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A

Where a bench vice and Stillson wrench are not available, we have found it convenient to modify the exit of the retort, using flanges with nuts and bolts, and an asbestos joint, instead of the threaded socket. In this way the retort can be closed by means of a couple of small wrenches. In field work this reduces the weight of gear which has to be transported.

(2) For ammonia determination alone, this retort can conveniently be replaced by one of 20 in. × 1 in.

D[1] is an asbestos board, with a few ventilation slits, which is placed over the retort, leaving a space of about ½ in. It is advisable to insert a piece of iron gauze at the inlet end of the retort, to prevent choking of the steam entrance when filling.

F is an ordinary 20-in. Liebeg condenser, connected to the Tee union through a piece of iron pipe 6 in. long, by means of a cork.

G A Wolff's bottle of 1000 c.c. capacity, for collection of oil and condensed water.

H A Davis condenser for further condensation of the lighter vapours.

K & K[1] are wash bottles of the Dreschel type, charged to about 3 in. deep with solar oil, for gas scrubbing purposes, in the case of oil determination only, or with dilute sulphuric acid (2 water to 1 sulphuric acid), in ammonia determinations.

L A carboy filled with water and fitted with a syphon for measuring the gas evolved, and at the same time producing a slight vacuum.

M A graduated cylinder for measuring gas evolved by water displacement.

Method of Procedure.—One thousand grm. of shale are weighed into the retort, the reducing socket at the exit end being removed for this purpose, and in order to ensure a gas-tight joint, which can be easily opened after use, the threads are painted with a mixture of blacklead and oil before screwing up. The apparatus is then tested for leaks by starting the syphon from L. The apparatus being tight, the gas under D is ignited, using a luminous flame. In the meantime, steam is raised in A, and allowed to escape through drip-cock at C, until it reaches a temperature of 180° C.

As soon as water vapour is seen to condense in F, steam is gently let into the retort, and the flames below the retort gradually increased, so as to keep the oil flowing into G at a steady rate during the whole

run. The amount of steam put through should be at least one-third of the weight of shale taken. The rate of flow to ensure this is quickly learned by experience. When oil ceases to be evolved, the temperature of the retort is raised to dull red heat, to ensure completion of the operation, and to obtain maximum gas yield.

Retorting without Steam.—This is as a rule only employed for rough experiments and field work, because in general the yield of oil is about 20% lower than when steam is employed. In such a case, in place of F it has been found that a plain glass air condenser is sufficient for all practical purposes, and a graduated cylinder alone is sufficient for collecting and measuring the oil.

A small iron retort made of 2-in. pipe and to hold approximately 100 grm. and heated by a Primus stove, has been found by us to give very informative results on field work, and obviates the necessity of the transport of large numbers of samples.

At the Colorado School of Mines, a pot-shaped retort is employed; but we prefer the tube shape, the oil vapours not being so subject to condensation on the top surface, with consequent running back and cracking.

Where initial cost of apparatus is not a controlling factor we recommend the substitution of the gas furnace shown in the sketch by an electrical resistance tube furnace, the cost of which would be about £35. The use of such a furnace, which can be regulated to any desired temperature, would be of great advantage when experimental work is being carried out on a new shale to determine the optimum temperature for retorting, also it ensures an even temperature all round the retort, thus preventing local overheating.

Determination of Nitrogen.

(a) *Total Nitrogen.*—This can be conveniently determined by the Kjeldahl method on shale dried at 100° C., the results being calculated on the original weight of undried shale. It is necessary to add anhydrous copper sulphate in order to complete the reaction. It is, of course, well known that there is no direct relationship between total nitrogen and that evolved as basic compounds, but it serves as a useful indication when the character of the shale is known.

(b) *Nitrogen evolved as Basic Compounds.*—As mentioned in the preceding section, these basic compounds are generated by retorting at a high temperature in the presence of steam.

In charging the retort for this purpose, the shale is placed in the middle section of the retort, the two ends being filled with ignited broken fire brick. Heating is commenced at the ends, which are brought to a dull red heat before direct heating of the shale is begun.

Superheated steam at 180°–200° C. is then admitted, and the whole retort is rapidly heated to a dull red temperature.

The operation is carried out in this manner, in order to produce as little oil and as large an amount of gas as possible.

The vapours are cooled and partially condensed by condenser F, and collected in G, which contains about 200 c.c. of dilute sulphuric acid (2 vols. H_2O, 1 vol. H_2SO_4), the uncondensed vapours being scrubbed in K & K^1 by means of the same reagent.

On completion of the retorting the acid from G, K & K^1 is bulked, and made up to 1000 c.c., and the ammonia estimated in an aliquot portion of this, by the usual method of neutralising by caustic soda and driving off into standard acid, the ammonia yield being calculated to pounds of ammonium sulphate per ton of shale.

Alderson (*The Shale Oil Industry*, New York, p. 99, 1920) states that in the Colorado School of Mines, ammonia in the liquors is estimated by means of formaldehyde according to the following equation :—

$$6\,HCHO + 2\,(NH_4)_2SO_4 = (CH_2)_6N_4 + 2H_2SO_4 + 6\,H_2O,$$

the sulphuric acid formed being then estimated by titration.

Examination of the Crude Oil.

(a) *General Characteristics.*—The general characteristics are determined as in the case of ordinary crude petroleum oils. These include :—

Specific gravity at 15° C.
Setting point.
Sulphur determination.
Water.
Engler distillation.

(b) *Distillation and Fractionation.*—We prefer to carry out this part of the examination in a manner similar to works practice, that is, distillation by external heat, assisted by the introduction of superheated steam, the primary fractions being cut according to the figures obtained in the Engler distillation.

The first fraction, light naphtha, volatile below 150° C., is taken off without the use of steam. At this point steam is introduced, and the heavy naphtha 150°–200° C. is separated.

As the distillates from 250°–300° C. obtained from many shale oils are somewhat high in specific gravity, we usually split the portion volatile between 200°–300° C. into two portions, 200°–250° C. and 250°–300° C., the former being classed as light kerosene distillate and the latter as heavy. The heavy oil distillates containing paraffin wax

are collected in fraction 5 or 10% each, the distillation being continued to dryness.

The crude naphthas are then redistilled over a Young's 12 pear column, the fraction below 150° C. being first distilled to this temperature, the heavy naphtha is then added to the residue, the portion volatile below 150° C. being added to the light naphtha, and distillation then continued to 200° C. for heavy naphtha. At 200° C. the light kerosene is added to the residue and distillation again carried out to 200° C., the distillate being added to the heavy naphthas. The kerosene, after Engler distillation, is separated in a similar manner, except that a plain still head is used and steam introduced to prevent cracking, the residue in the still being classed as gas oil.

The heavy oil fractions are tested for specific gravity and set point, prior to bulking them for paraffin wax determination; fractions, however, having a setting point below 32° F. (0° C.) are not included. The paraffin content is determined by Holde's or a similar method, the percentage being calculated on the total crude.

Experimental Refining.

Refining experiments are now carried out on the naphtha and kerosene fractions, with a view to the production of samples of marketable value and estimation of refining losses. It is our experience, after testing the products of shale from varied sources, that many of them are not amenable to ordinary refining methods, on account of the large percentage of unsaturated compounds, and consequent high refining loss, even when commercial quantities only of acid are employed, and unless a large excess of acid is used the finished products, although initially water white, after a short time revert in colour. We have, however, devised a method which has given invariable success in the treatment of the lighter fractions, the finished products being stable in colour and the losses low.

This consists in passing the oil in a state of vapour through a column of heated fuller's earth, bauxite, etc.

We have usually confined our refining experiments on the bulked heavy oil fractions to determinations of losses on acid and soda treatment, classing the refined product, after making allowance for paraffin wax content, as gas and lubricating oil stock; since we consider that in experiments which start with less than 5 gall. of crude, results of practical value with regard to lubricating oil are not obtainable.

At this point, a peculiarity might be mentioned which we noticed in the examination of a crude Colorado shale oil, retorted by a special process in which considerable volumes of inert gases were employed

	Colorado Shale Oil.	Finland Shale.	Spanish Shale.	Swedish Shale.	Colorado.	Norfolk.	Var (Boson).
Specific Gr. at 15 C. =	0·895	0·941	0·948	1·002	·912	·973	·868
Sulphur =	0·73%	0·87%	5·07%	4·17%	—	4·5%	0·3%
Engler Distilln.							
Vol. below 150° C.	7·9%	23·5%		12·0%	12·5%	11·0%	8·0%
150°–200° C.	8·6%					10·5%	9·0%
200°–250° C.	25·0%	24·0%		15·0%	8·5%	11·5%	9·5%
250°–300° C.				18·5%	11·5%	9% (to 250°)	11·5%
300°–350° C.	14·0%						15·0%
Finished Products.							
Motor Fuel	16·5%	19·1%		11·5%	9·15%		17·4%
Lt. Kerosene	10·0%	9·6%		14·6%	7·52%		10·6%
Hy. Kerosene	9·0%			18·0%			
Gas Oil	14·0%				21·47%		19·7%
Paraffin Wax	2·2%	nil		nil	3·5%		5·15%
Lub. Oil Stock	27·2%	nil		22·5%	13·2%		25·05%
Fuel Oil	—	48·2%			26·2%		1·14%
Dist. & Refining Losses	21·1%	23·1%		33·4%	18·96%		20·96%

to remove the oil vapours as quickly as possible from the heated zone, in order to prevent cracking.

The untreated heavy oil and paraffin fraction had a specific gravity of 0·930 at 15° C.; on treatment with 3% of 96% sulphuric acid there was apparently a loss of 45% as acid tar. The washed oil had specific gravity 0·905 at 15° C., and was much higher in setting point than the original, being quite solid at ordinary temperature. We found on neutralising the acid tar with caustic soda, that practically the whole of the oil apparently lost was recoverable. This oil had specific gravity 0·964 at 15° C., and was quite fluid at ordinary temperatures.

The accompanying table gives a series of results, which have been obtained from shales of widely varying origin, by these methods.

Unsaturated Hydrocarbon Content.—This is estimated on the finished product in the usual manner.

Notes on the Weathering of Shale.

One of the most general beliefs regarding the behaviour of shale is the idea that exposure to weather, above ground, rapidly lowers the quantity of oil to be obtained by retorting.

Some three years ago, one of us had occasion to test the truth of this belief when working at the Boson shale mine in the south of France. A large block of rich shale was taken direct from the mine, broken into small lumps, well mixed, quartered to get a fair sample, and at once retorted in the laboratory apparatus. One half of the sample was spread out on a wooden tray and left in a position where it was fully exposed to all weather conditions, and at previously decided intervals of time a fair sample was taken and the oil yield determined, all tests being carried out in duplicate, and as far as possible a weather record kept.

Much to the general astonishment—and we may even say, incredulity—it was found that for a certain period at the commencement of the test the yield curve rose steadily and rather steeply, then descended a short way, and remained steady for a period of six months, as shown in the appended table.

In order to compare the effects of rain and sun with that of air only, the second half of the original sample was kept under shelter in an airy shed and retorted at the same intervals as the fully exposed shale.

	Original.	17 days.	28 days.	8 months.
		Litres per 1000 K. grm. dry shale.		
Fully exposed	550 L.	604 { 133 G. ·863	572 { 126·1 ·865	580 { 127·7 ·863.
Under cover	121 G. ·862 S.G.	556 { 122·5 G. ·867	574 { 122·5 ·861	— —

	Original.	8 hrs.	7 days.	14 days.	21 days.	28 days.	2 months.	4 months.
Exposed to all weathers	71·9 L. 15·8 G. ·973 S.G.		78·9 L. 17·4 G. ·976		86·4 L. 19·03 ·986	80·9 L. 17·85 ·981	74·5 L. 16·4 G. ·990	60·0 L. 13·2 G. ·987
Kept under cover	71·9 L. 15·8 G. ·973 S.G.		71·1 L. 15·7 G. ·973	71·2 L. 15·7 G. ·973		69·4 L. 15·3 G. ·978	69·7 L. 15·35 ·987	60·83 13·4 G. ·985
Exposed to sun and air but not rain	102·5 L. 22·6 G. ·988 S.G.		103·5 L. 22·8 G. ·990				94·9 L. 20·9 G. ·987	
Dried at 100° C. in water-oven	71·9 L. 15·8 G. ·973 S.G.	71·04 15·65 ·972						
Dried at 120° C. in air-oven	71·9 L. 15·8 G. ·973 S.G.	70·4 L. 15·5 G. ·978 S.G.						
Dried in a current of hot air at 140° C.	102·5 L. 22·6 G. ·988 S.G.	100·0 L. 22·02 G. ·987						

The test lasted from September to July, during which time hard frost, heavy rain and hot sun were experienced.

The shale in this case was very rich torbanitic material, and it was not until the present year that sufficient time and opportunity occurred of testing an entirely different class of shale, that of Norfolk, which is an argillaceous deposit full of shells.

The test on Boson shale was carried out under very primitive conditions, but in view of the unexpected results obtained, greater care was bestowed on that from Norfolk, in order to be sure that no fallacy had been allowed to creep in.

Tests were carried out on Norfolk shale : (1) exposed to all weathers ; (2) kept under cover ; (3) exposed to sun and air, but not rain ; (4) dried at 100° C. in a water oven ; (5) dried at 120° C. in air oven ; (6) dried at 140° C. in a current of hot air.

In general the specific gravity of the oil obtained appears to increase slightly with increased length of exposure, up to a point ; but owing to the difficulty of always retorting in exactly the same manner not much reliance can be placed on these figures.

For the same reason the fractionations of the oils obtained cannot be regarded too seriously, though the general trend points to a decrease of lighter fractions with increase of exposure.

We much regret now that estimation of total nitrogen, nitrogen evolved as ammonia, and total volatile organic matter were not made at the same time as each of the oil determinations, in order to have a complete record showing the changes brought about by weathering conditions.

The experiments have not as yet been carried on far enough to warrant the postulation of any theory to account for the rise in oil yield produced initially by exposure to weathering, and a greater variety of shales will have to be tested, and a deeper study of the phenomena made before the question can be answered.

The figures obtained are given for what they are worth ; but in view of the present value of oil and the growing interest in the development of oil shales, it is thought that it will at least be of interest to briefly make known the fact that with certain shales under certain conditions, an increase of oil yield amounting to 9% and 20% can be obtained, at no expense, by seizing the right moment to retort the shale.

DISCUSSION.

Mr. W. Hardy Manfield said that as time did not permit of any discussion on Dr. Remfry's contribution, he should be glad if he would say through the *Journal* whether, when comparing the yield of oil from

freshly mined oil shale with the yield of oil from the same shale after being exposed to the weather for one, two or three months, an allowance was made for the moisture in shale and the water in the oil in each case, i.e. was the comparison made between the yields of water-free oil and dry shale.

He understood Dr. Remfry to assert that the Var oil shales, and to a less degree the Kimmeridge oil shales in Norfolk, gave a higher yield of oil after being exposed to the weather for one, two or three months than when just taken from the ground. This appeared to him to be not only improbable but impossible if the moisture content of the shale is the same in each case. Variations in the yield would of course occur if the method of restoring the shale differed or the temperature varied at a certain period during the distillation. His experience was that the hard, high-yielding beds of Kimmeridge shale in Dorset deteriorate very slowly when exposed to the weather, and the poorer or more friable beds more quickly. He would expect the same to be the case with the Kimmeridge shales in Norfolk. The rich shales at Boson in Var, where they had been exposed for many years, had certainly deteriorated, but he would not expect to find any appreciable difference in the yield of these or the hard Kimmeridge shales after exposure for two or three months only.

Dr. Remfry said in reply to Mr. Hardy Manfield's questions regarding the weathering of shale, it should be stated at once that when comparing the yields of oil obtained after different periods of weathering the calculations were invariably made on water-free shale, i.e. the weight of water given off during retorting was subtracted from the weight of shale taken, and the yield of oil calculated on the dry weight thus found. It seems almost superfluous to say that the oil was measured when water free.

Mr. Hardy Manfield's expression of incredulity at the results obtained is only another addition to the list of those who have already expressed the same sentiments.

So far, however, as the authors are aware, experiments of this kind have not been carried out before, or at any rate the results have not been published. As a general rule, shales have been retorted haphazard after indefinite periods of exposure, and from these results it has been given out that the effect of weathering is invariably to lower the yield of oil; but although this result does come about after a certain period of exposure it appears that the preliminary rise occurring during the first few weeks of exposure has not before been noticed or recorded.

It need hardly be said that the greatest care was taken always to

retort the samples in the same manner and at the same temperature, since it is well known that variations in these conditions will produce differences in yield of oil.

Although these experiments were originally undertaken with a view to ascertaining the rate of deterioration of a particular shale (Var), the unexpected course taken by the results turned the investigation into a more interesting and hitherto unexplored channel, which is in no way connected with the question whether friable or solid shales deteriorate the more rapidly under weathering.

The Resolution of Thanks proposed by the **President** was carried by acclamation, and the meeting terminated.

CRYSTAL PALACE LECTURES ON PETROLEUM.

The Council has arranged to publish in bookform a complete series of the Crystal Palace Lectures, which will be rewritten and illustrated with some ninety-two diagrams and plates. The work is to be issued as a Popular Petroleum Book for the general petroleum-reading world, with glossary, statistical tables (including various weights and measures for technical reference), and a bibliography and other useful information. The Council are anxious that the members should support this venture, and those members desiring to subscribe to the volume can obtain further information on application to the Secretary.

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